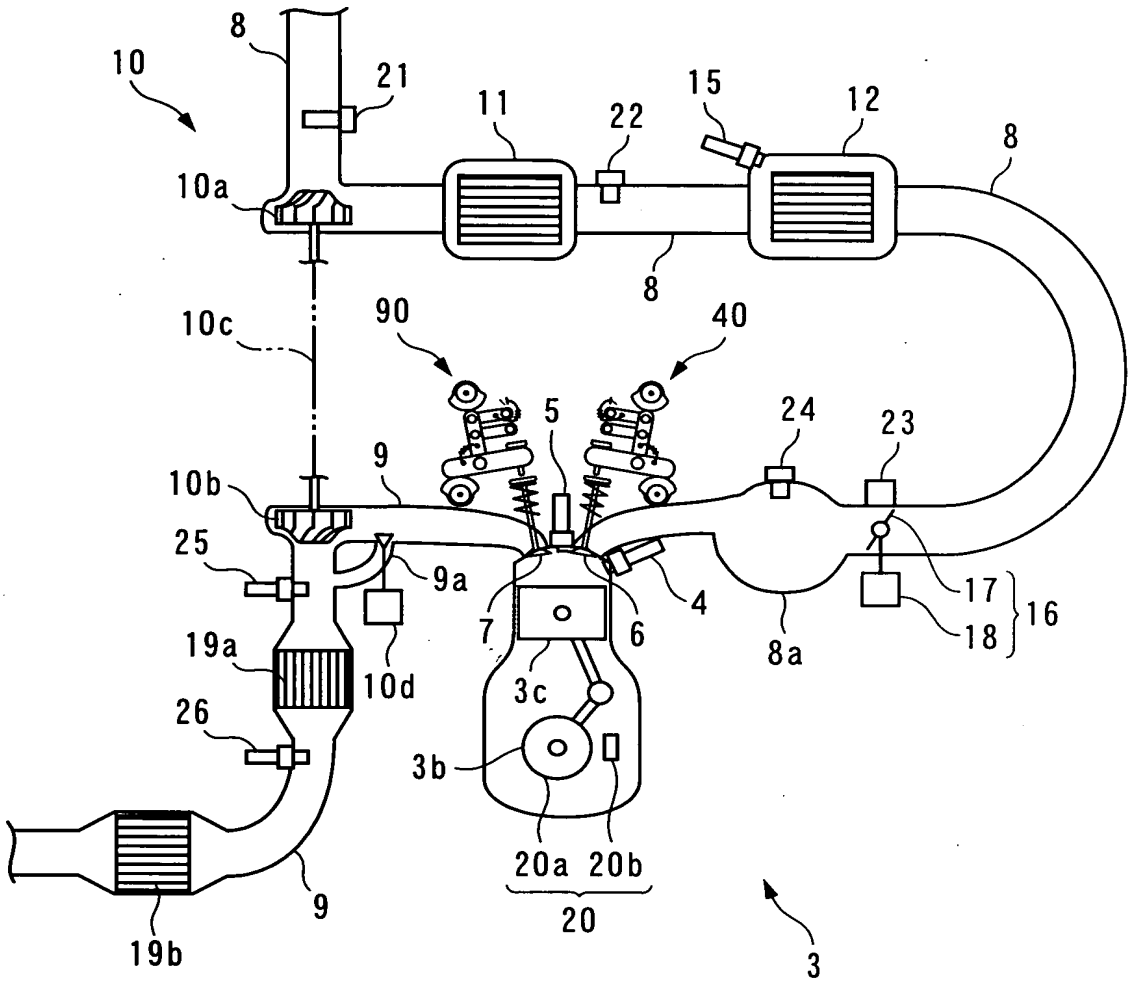
FIG. 1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F I G. 2

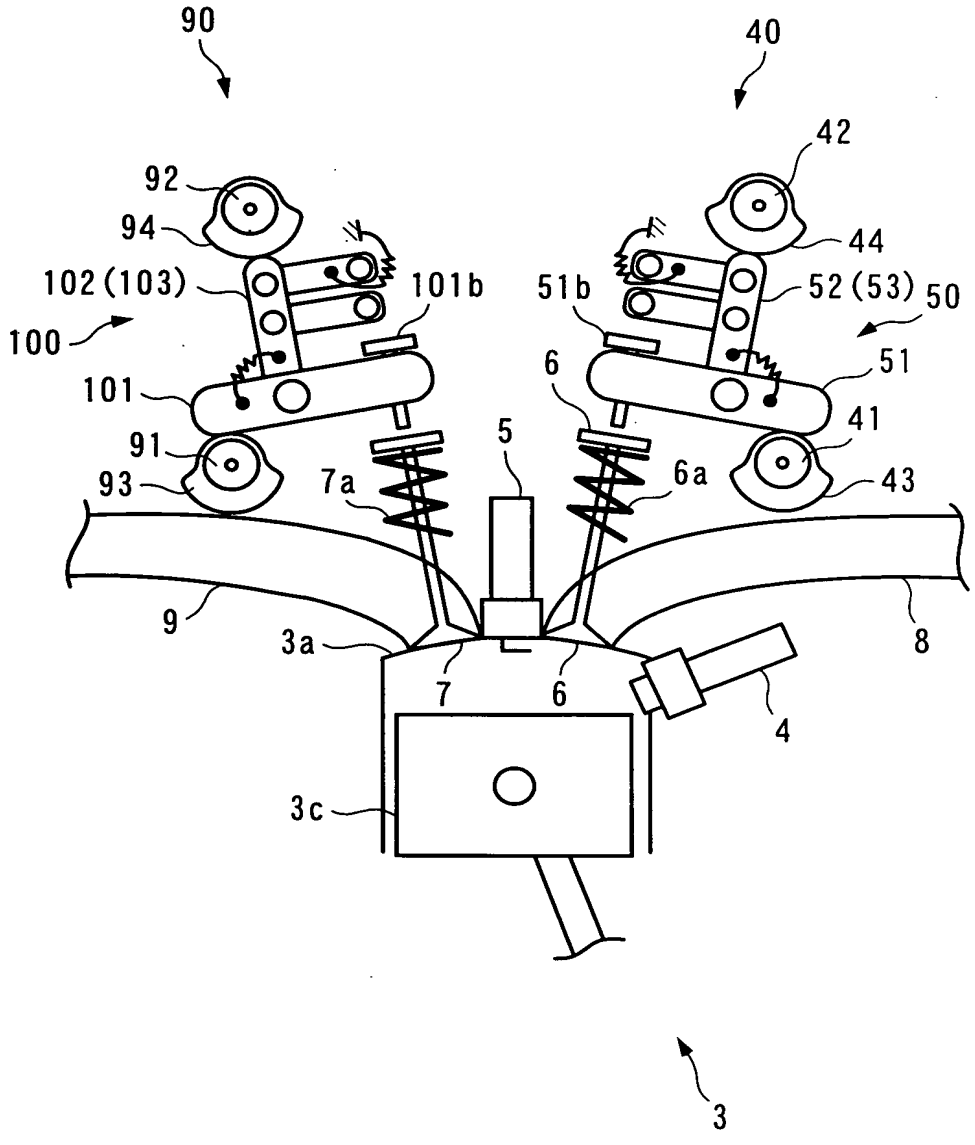

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FIG. 3

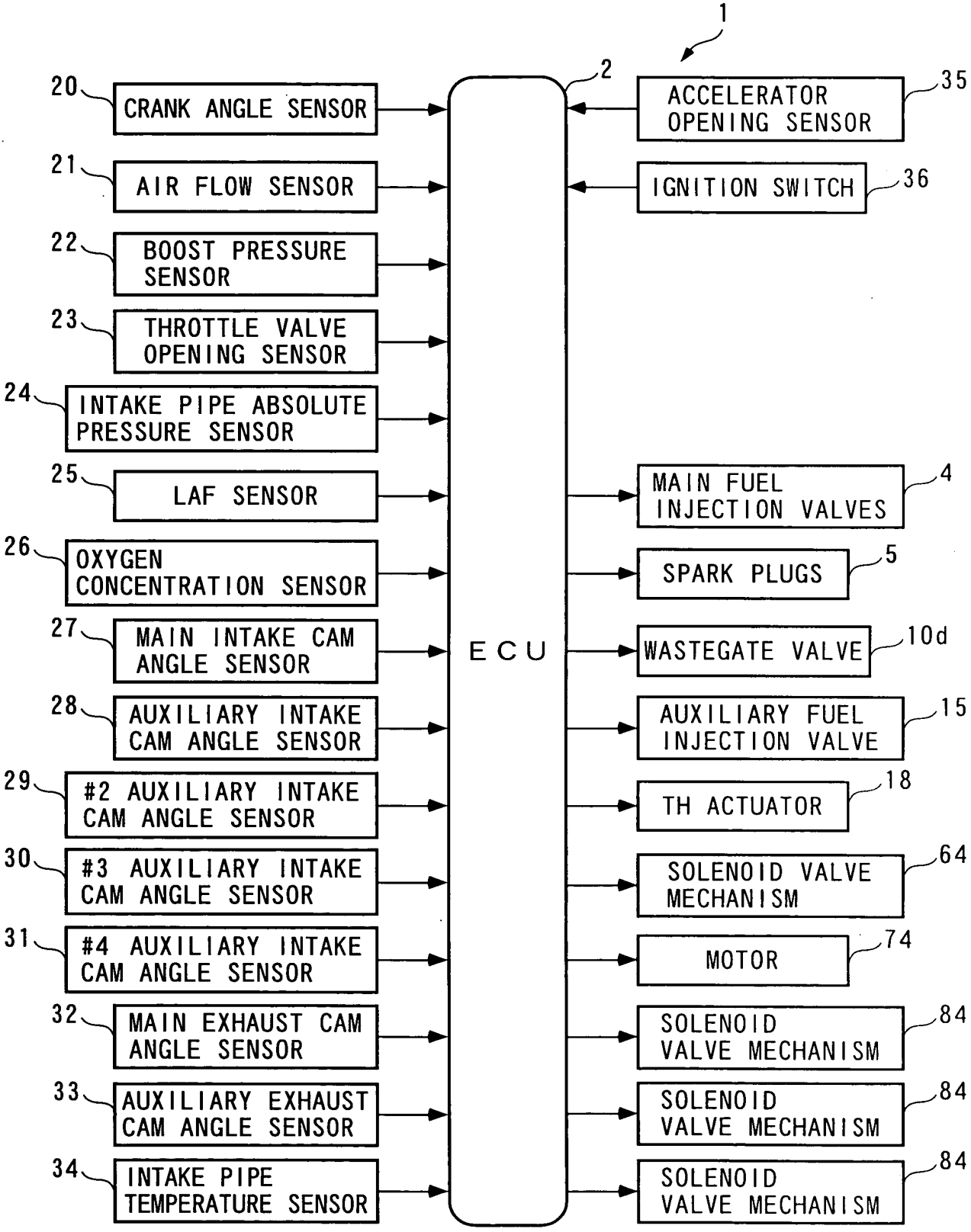

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FIG. 4

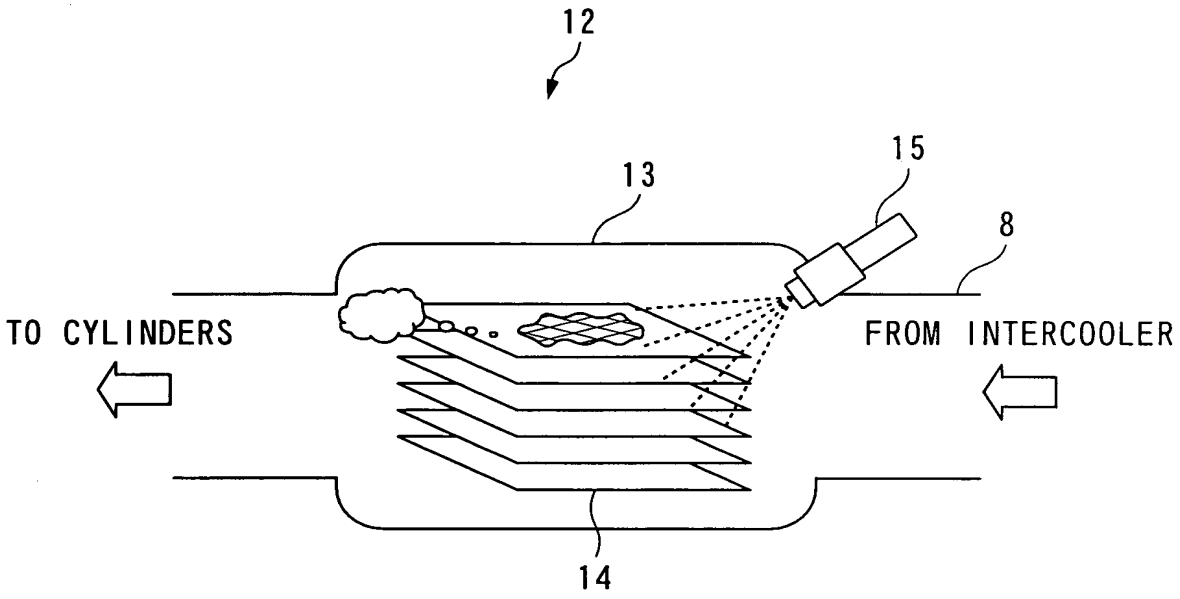

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FIG. 5

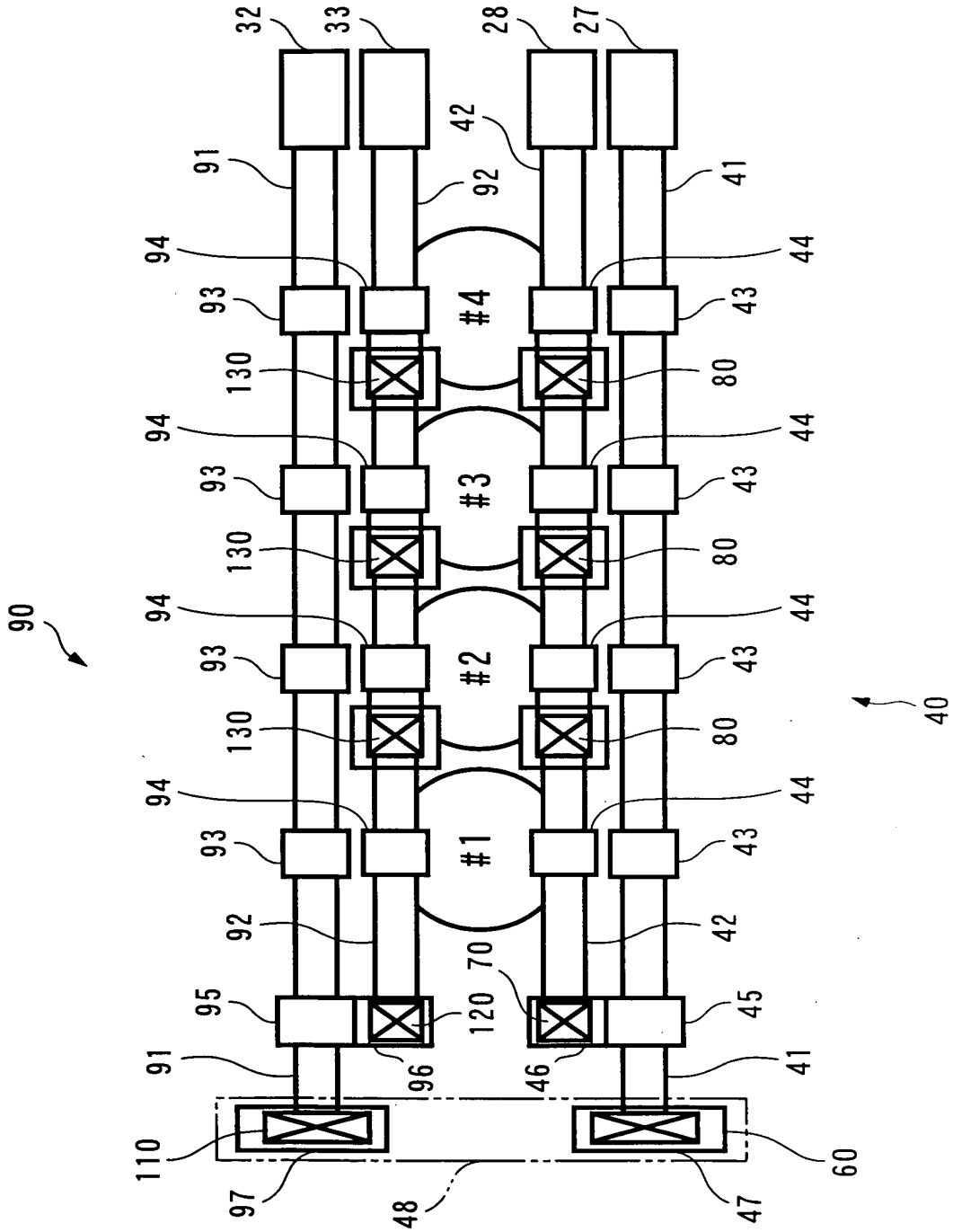

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FIG. 6

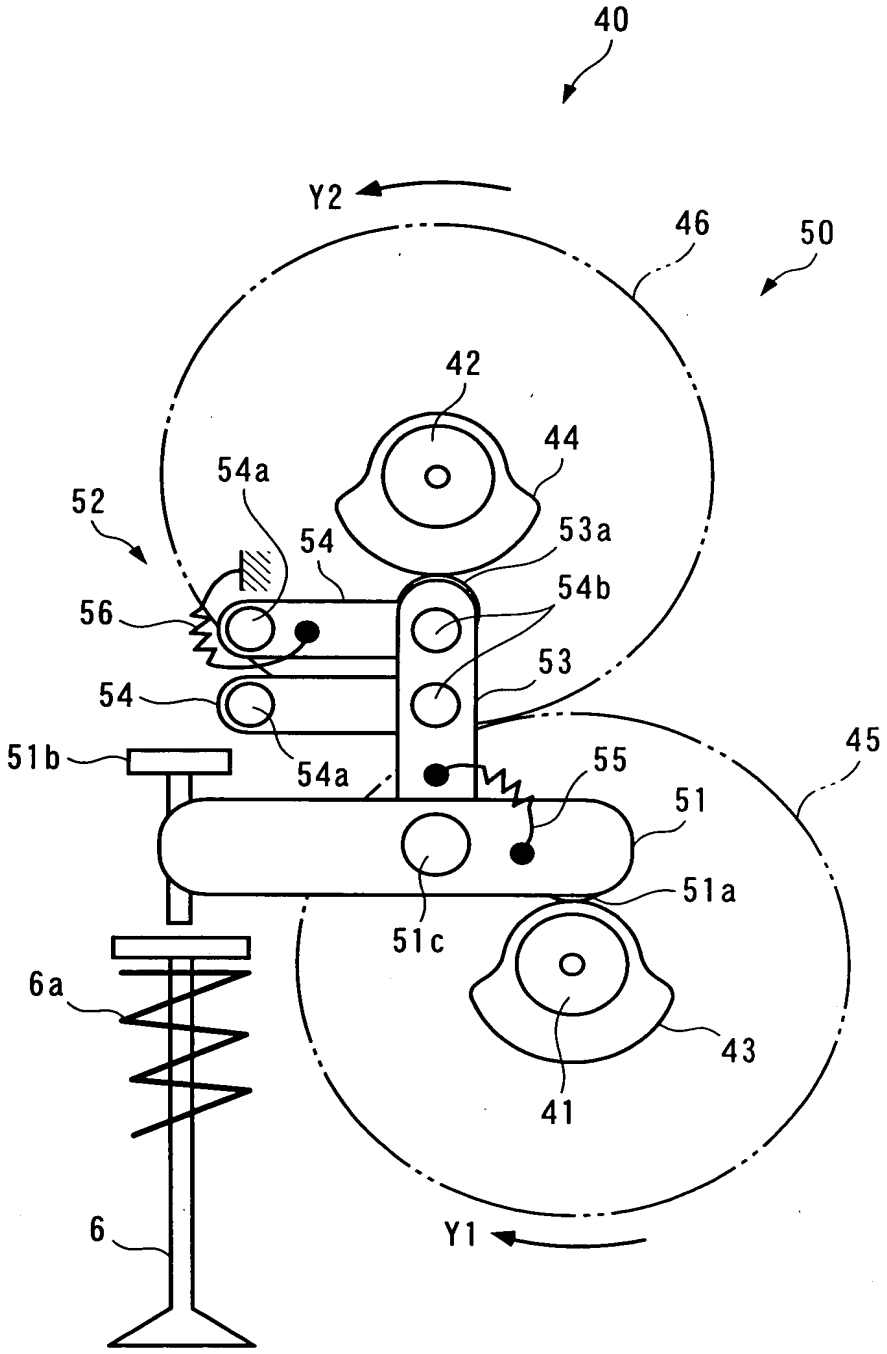

FIG. 7

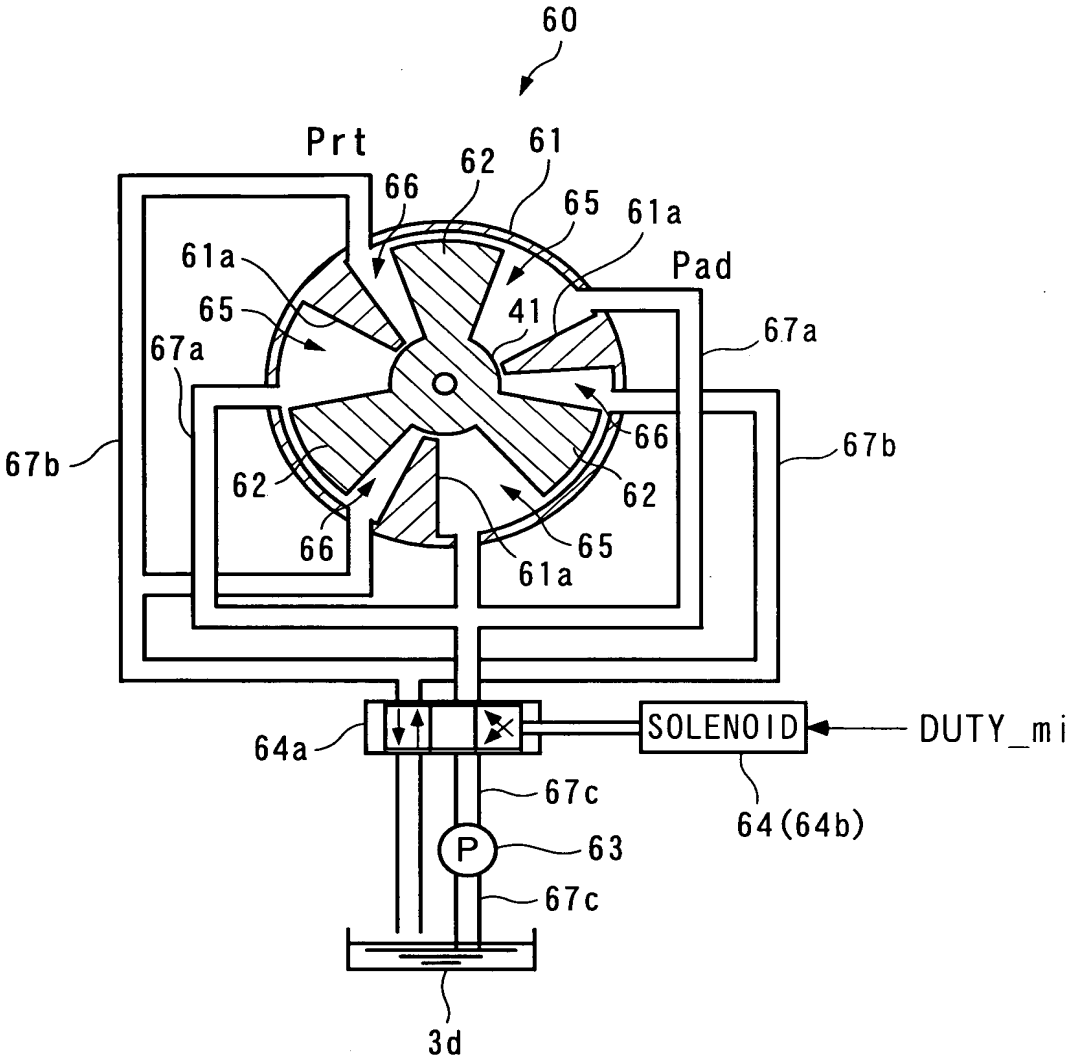
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FIG. 8

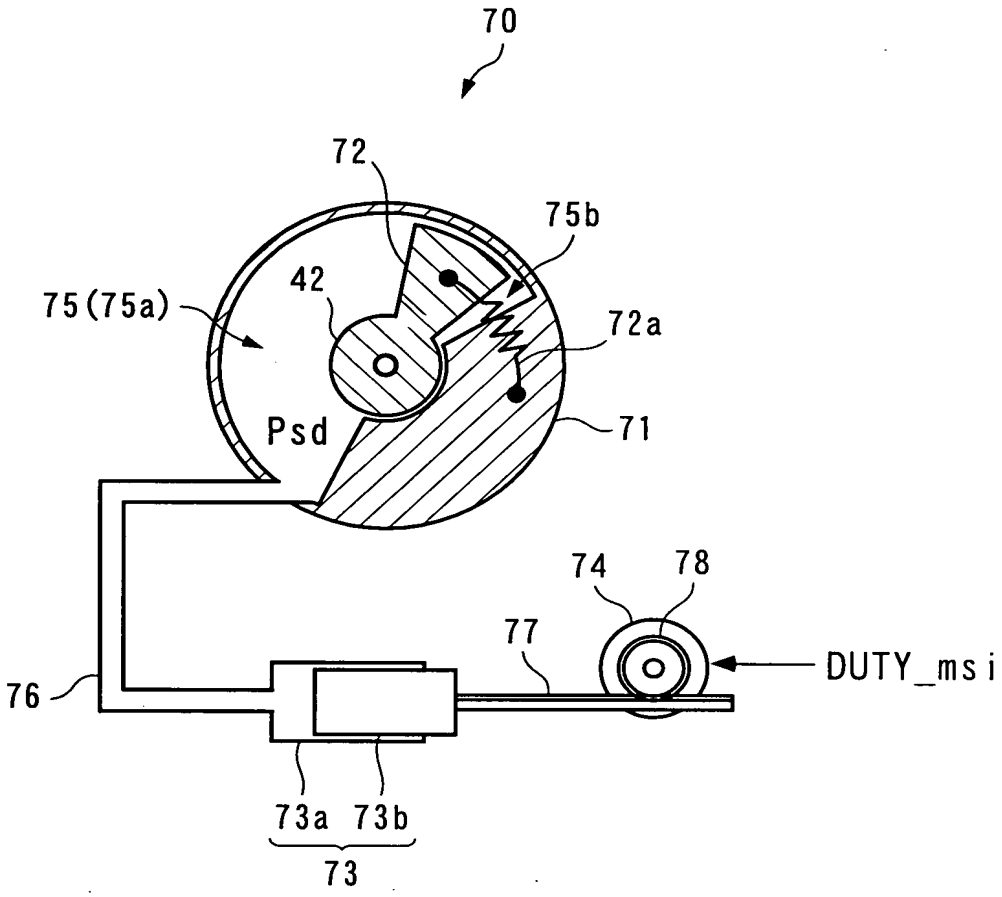

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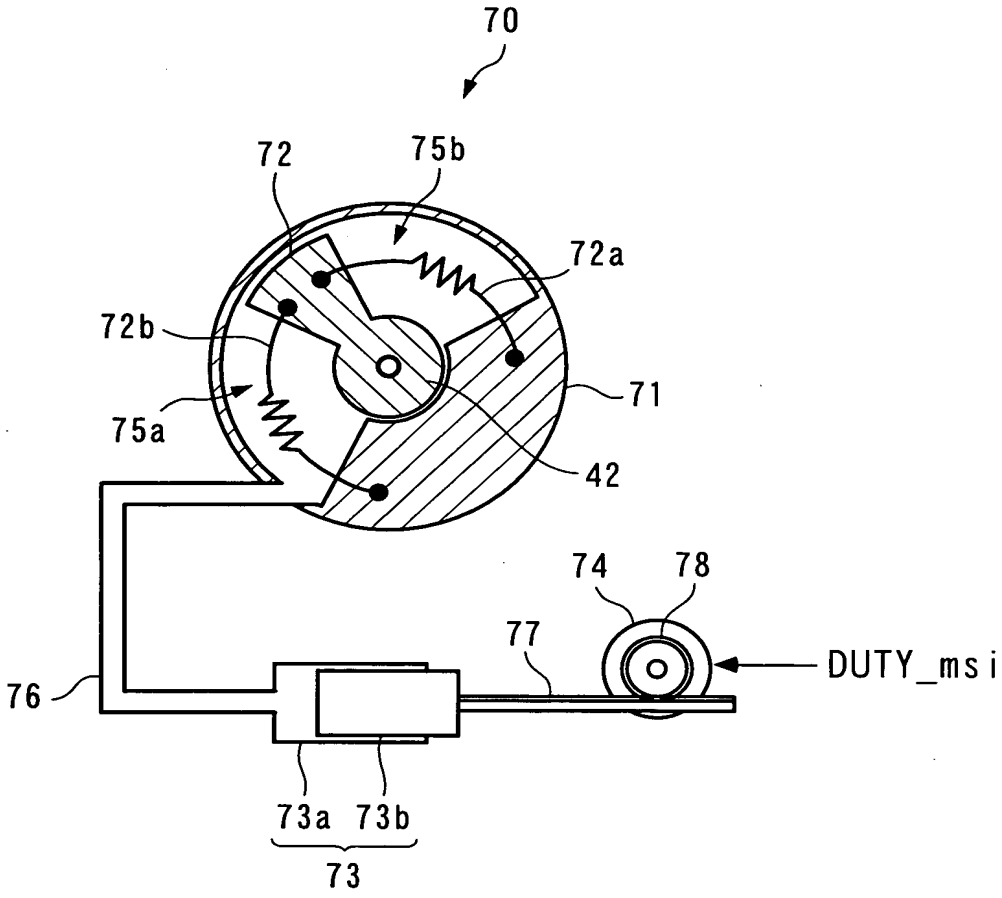
FIG. 9



Air Amount Control System For Internal Combustion Engine and Control System
Inventor: YASUI, et al.
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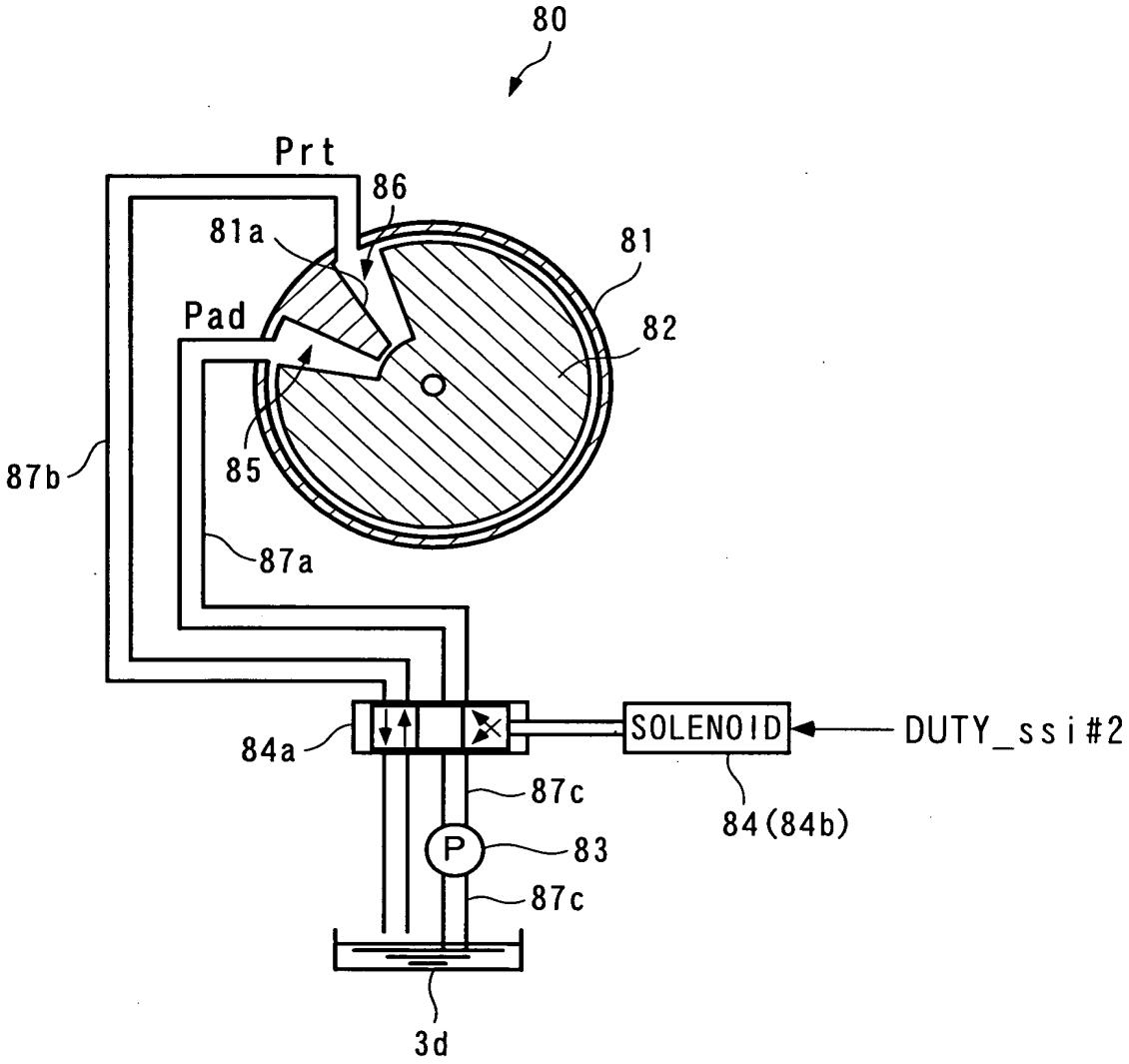
FIG. 10



Title: Intake Air Amount Control System For Internal Combustion Engine and Control System
Inventor: YASUI, et al.
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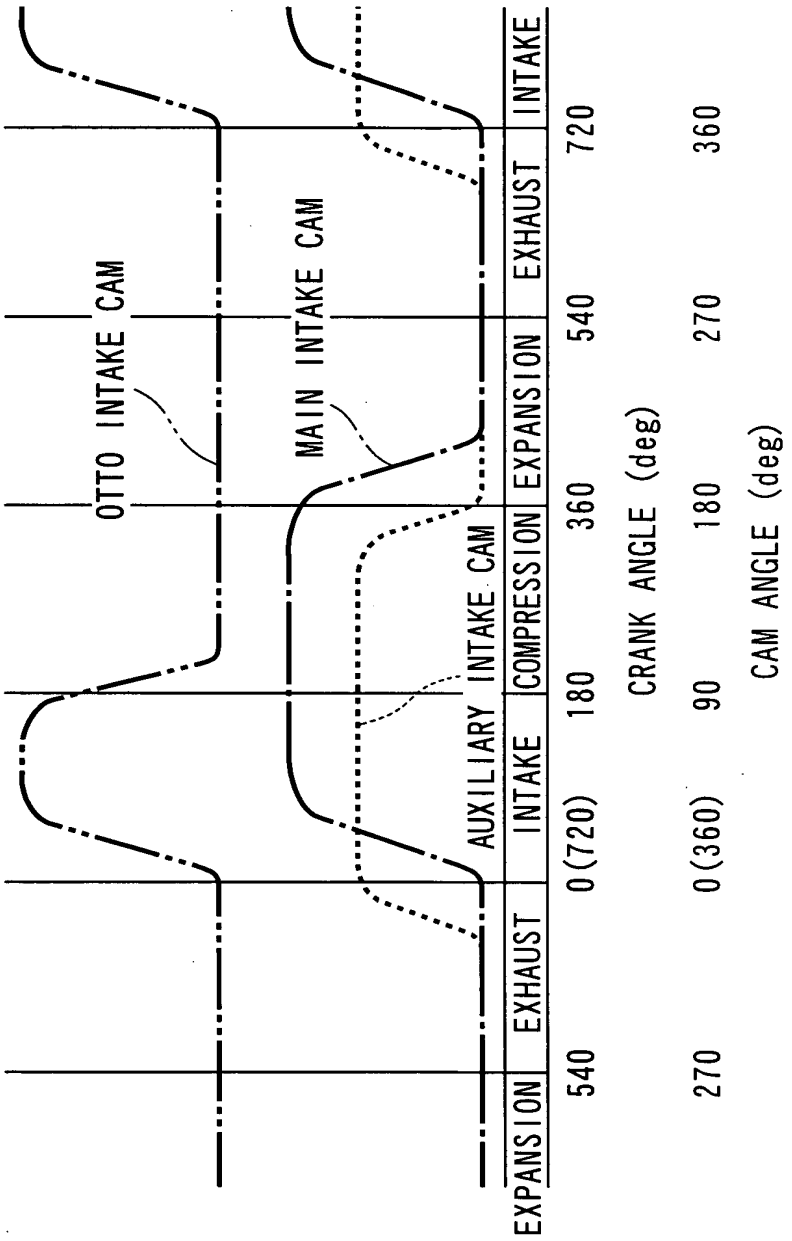
FIG. 11



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Inventor: YASUI, et al.
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FIG. 12A

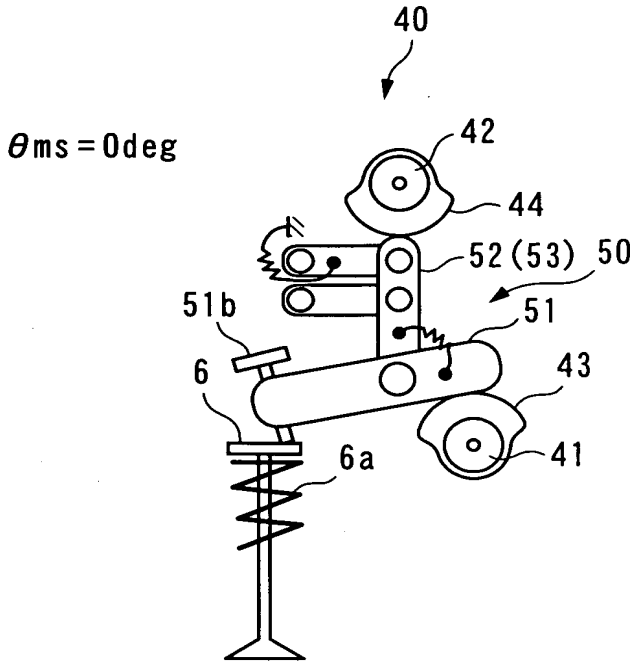

FIG. 12B

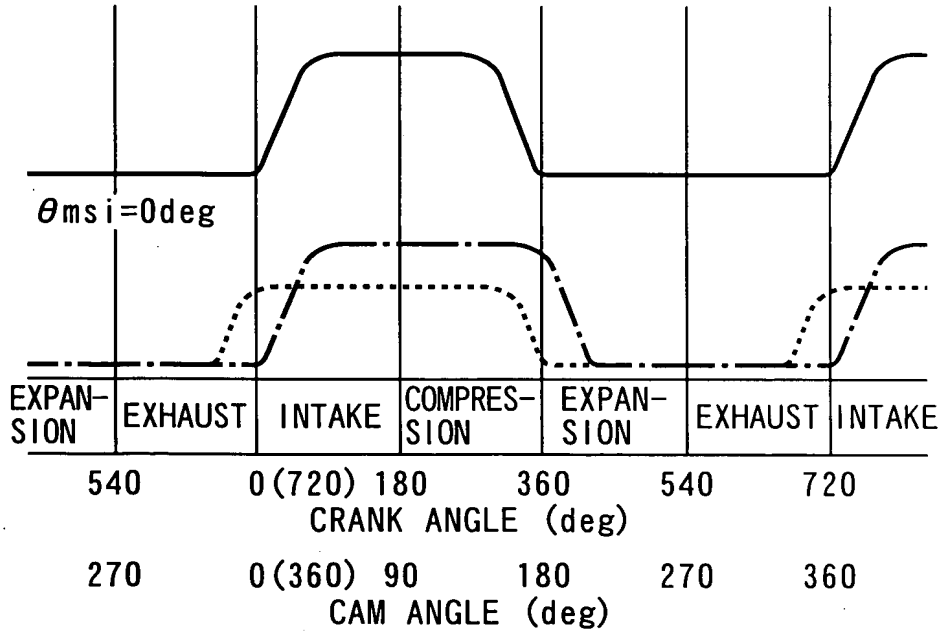

FIG. 13A

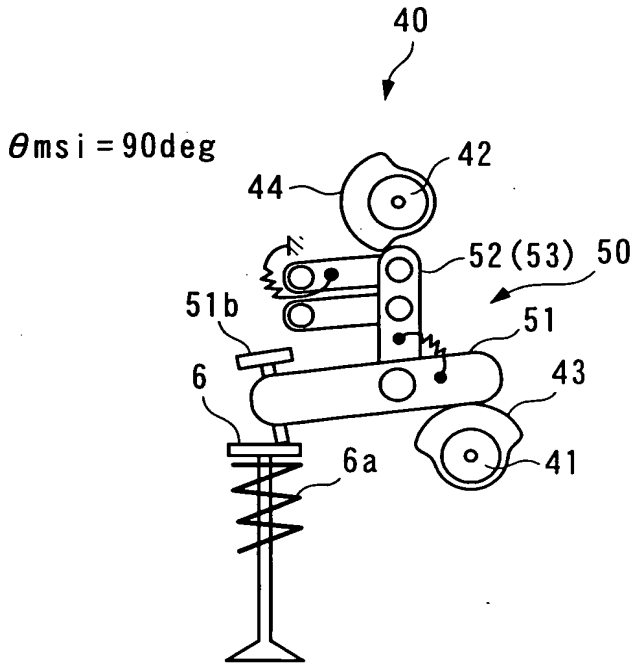

FIG. 13B

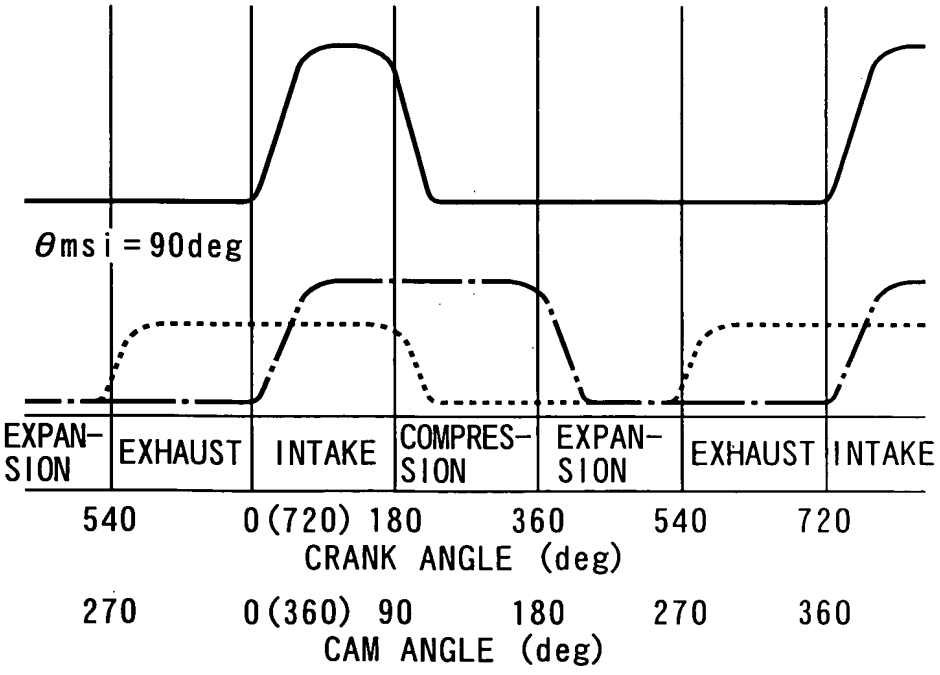

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FIG. 14A

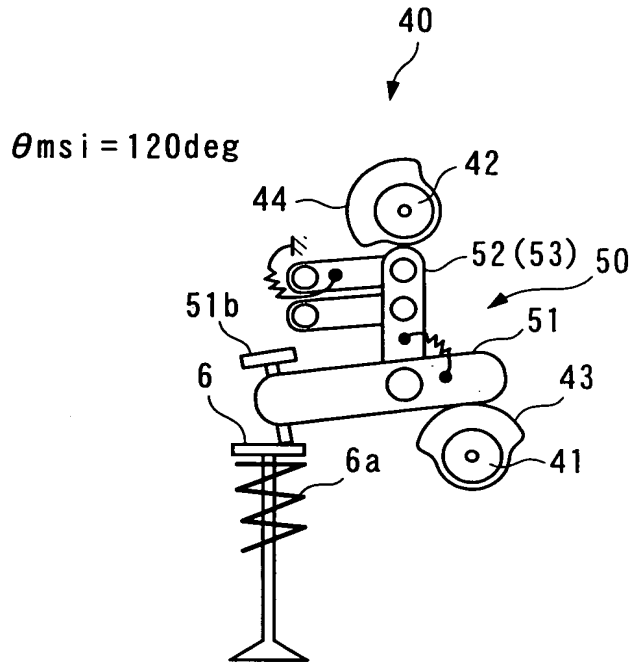

FIG. 14B

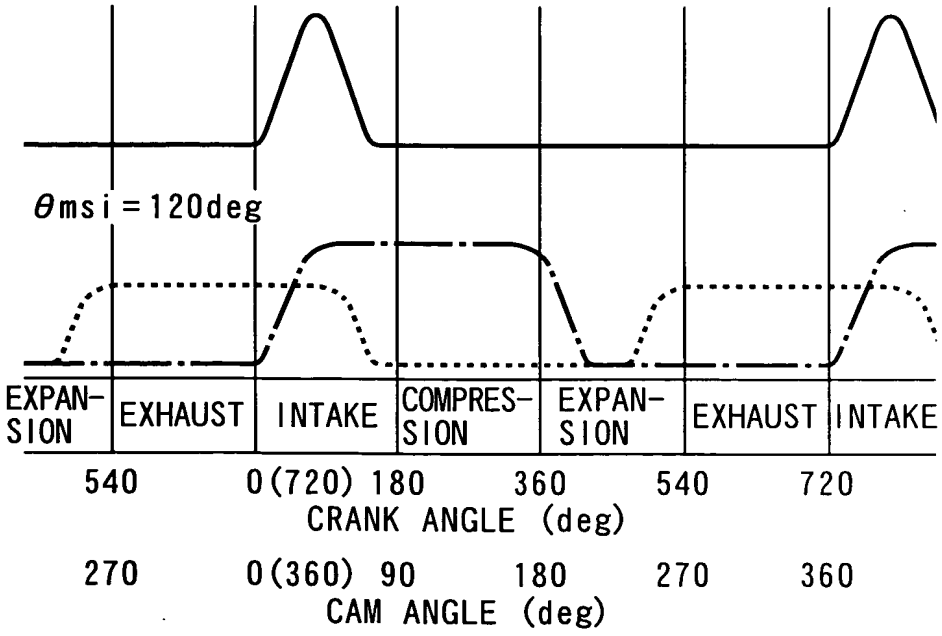

FIG. 15A

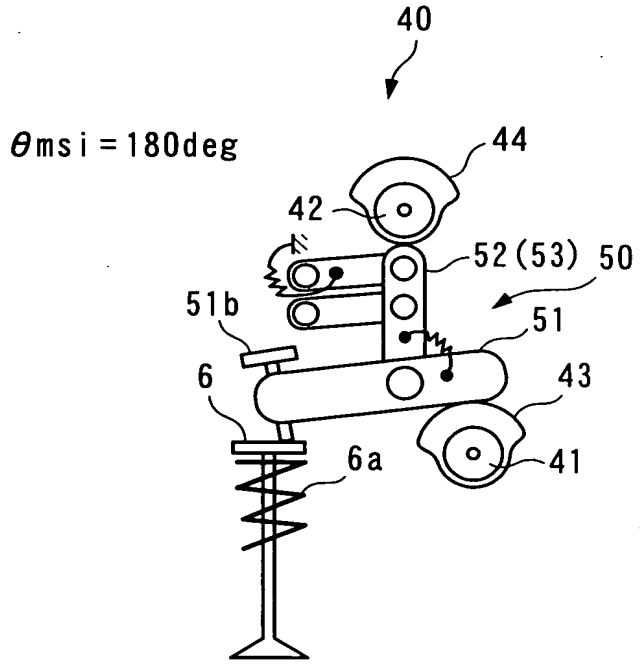

FIG. 15B

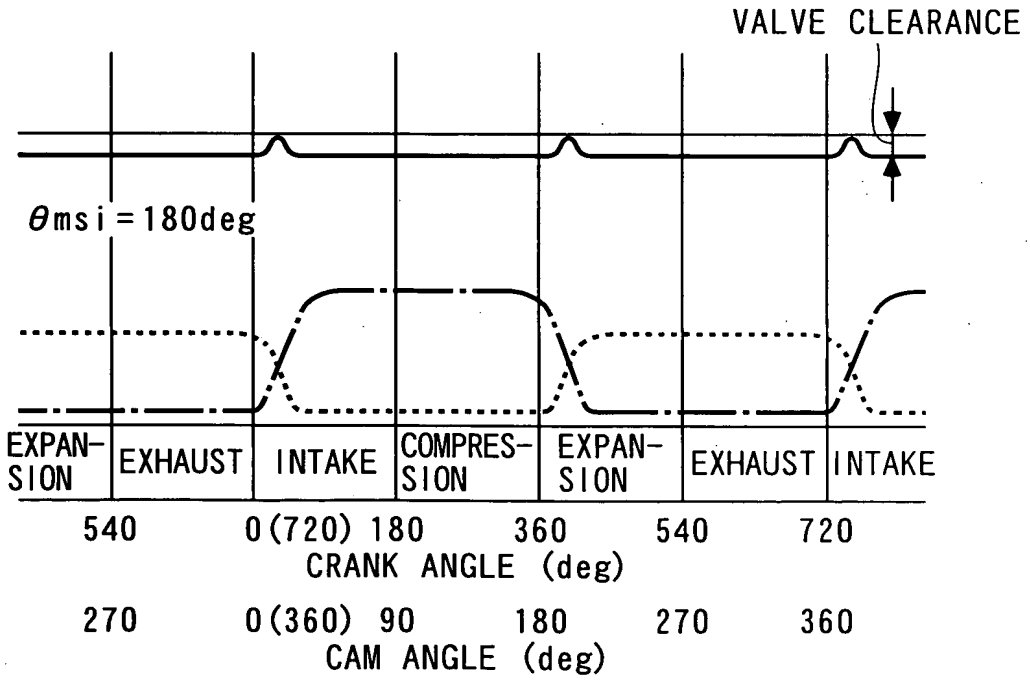

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FIG. 16

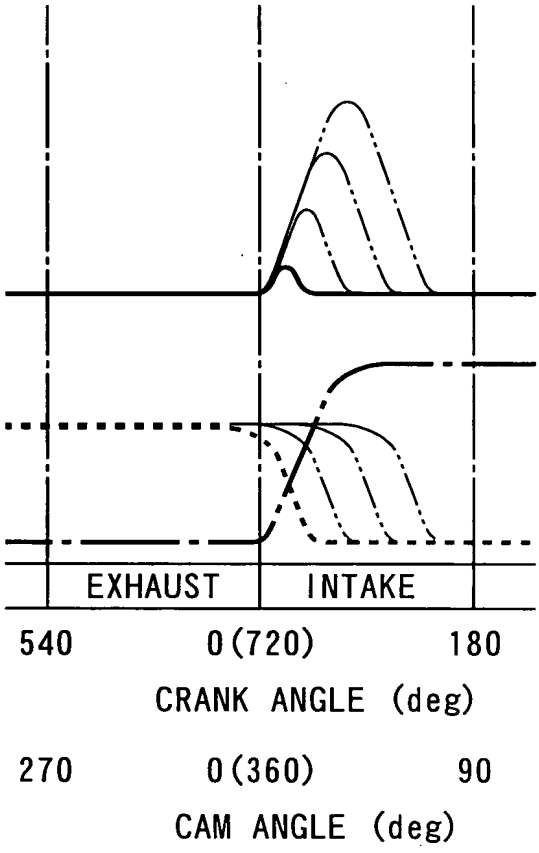

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FIG. 17

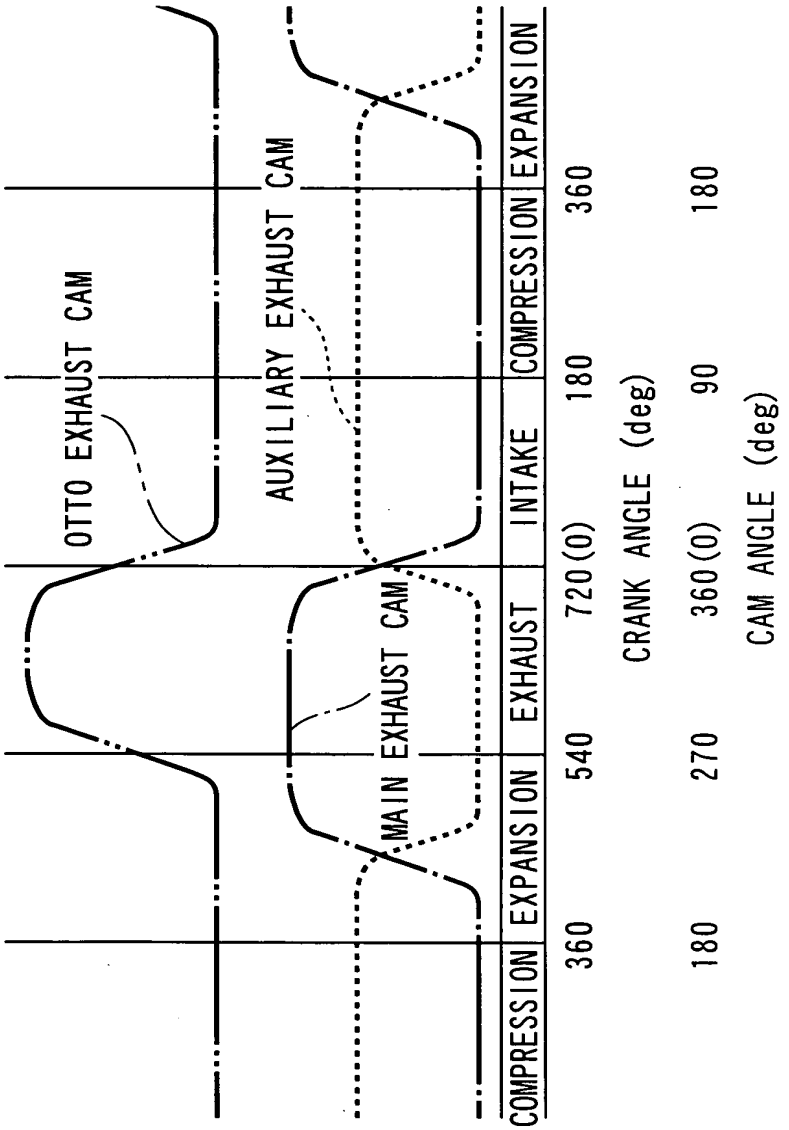

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FIG. 18

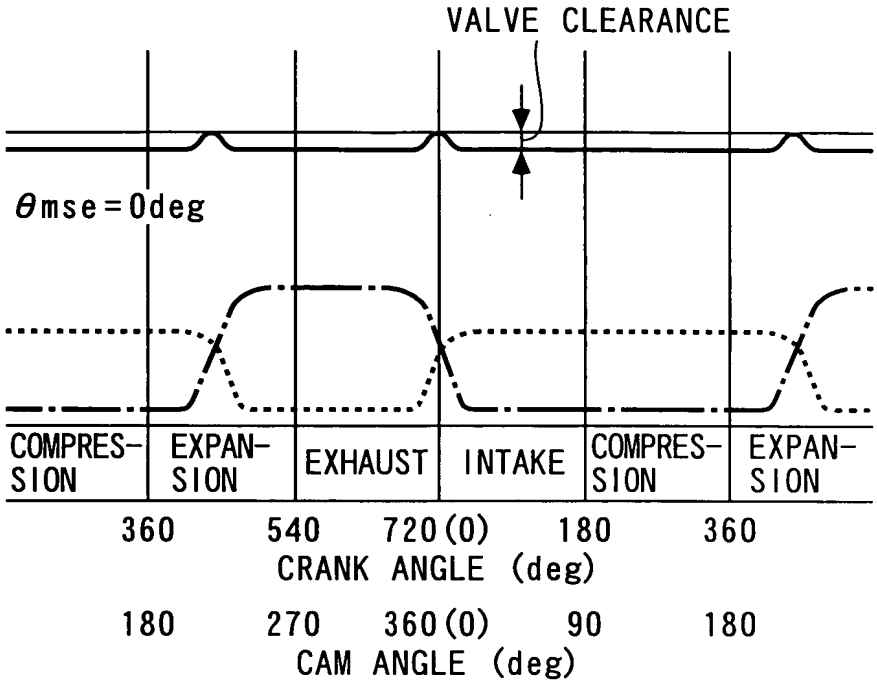

FIG. 19

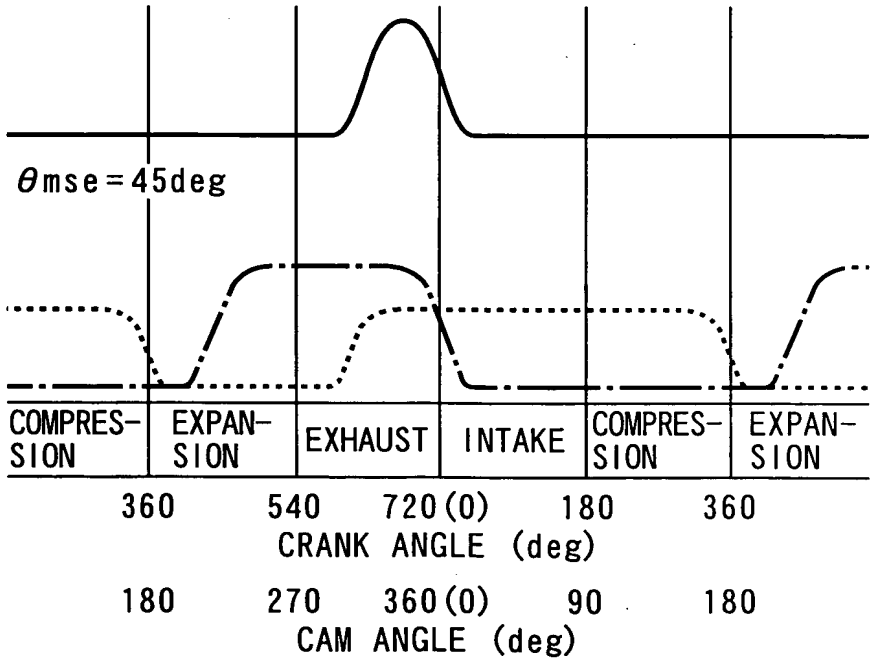

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FIG. 20

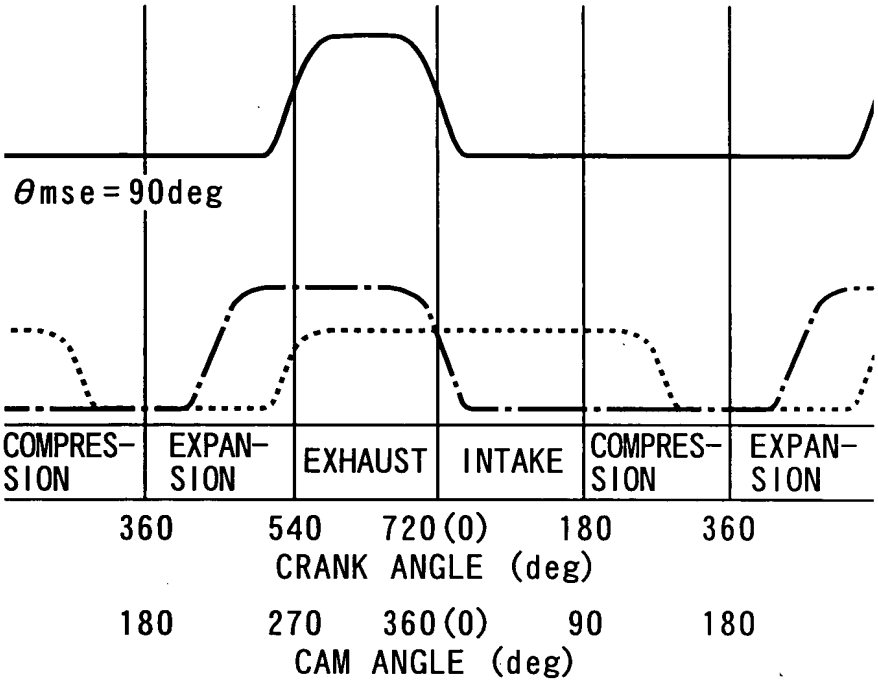


FIG. 21

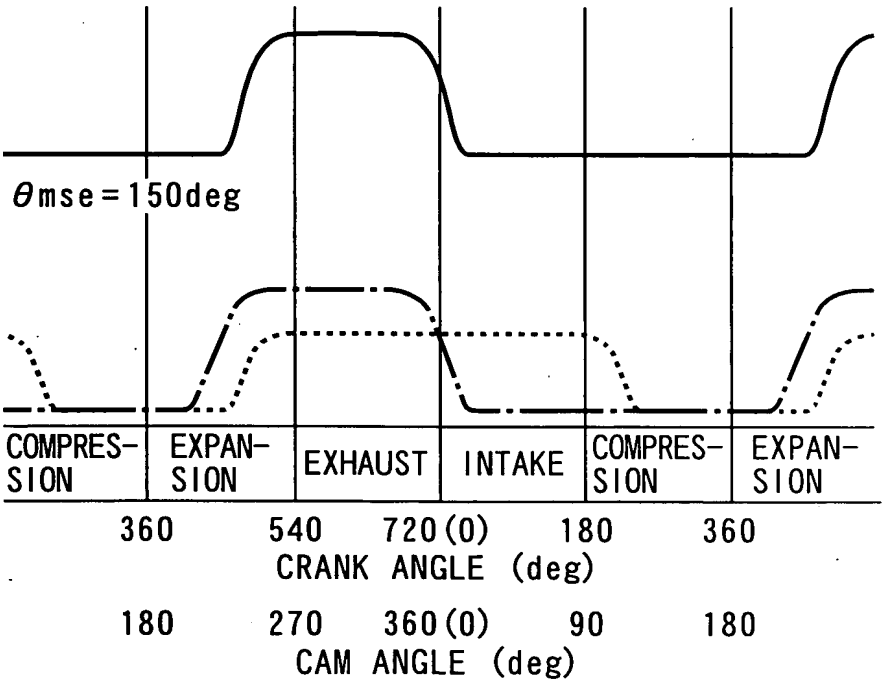
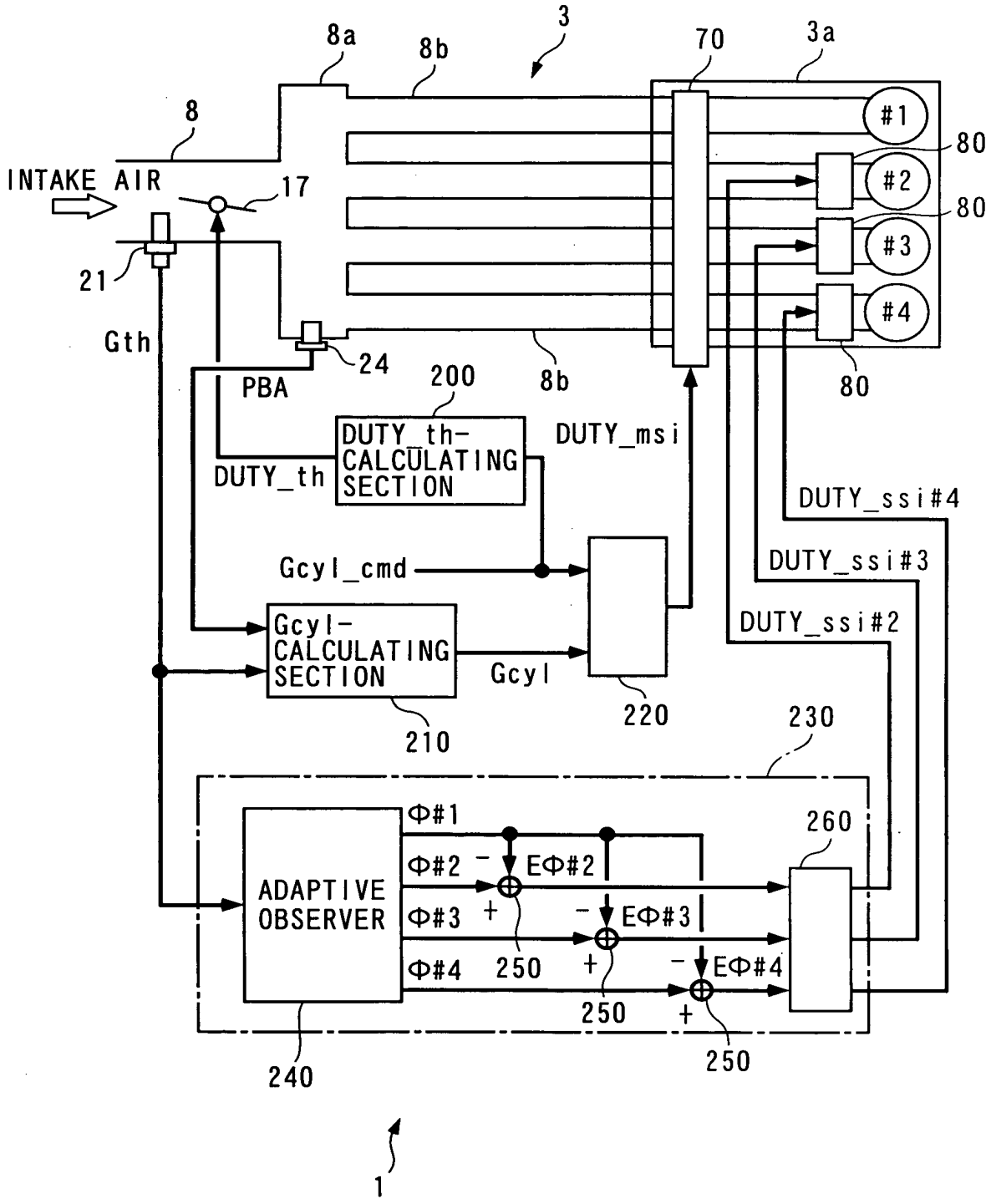


FIG. 22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200
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SECTION
DUTY_th
DUTY_msi
DUTY_ssi#4
DUTY_ssi#3
DUTY_ssi#2
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Gcyl-
CALCULATING
SECTION
Gcyl
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220
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260
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FIG. 23

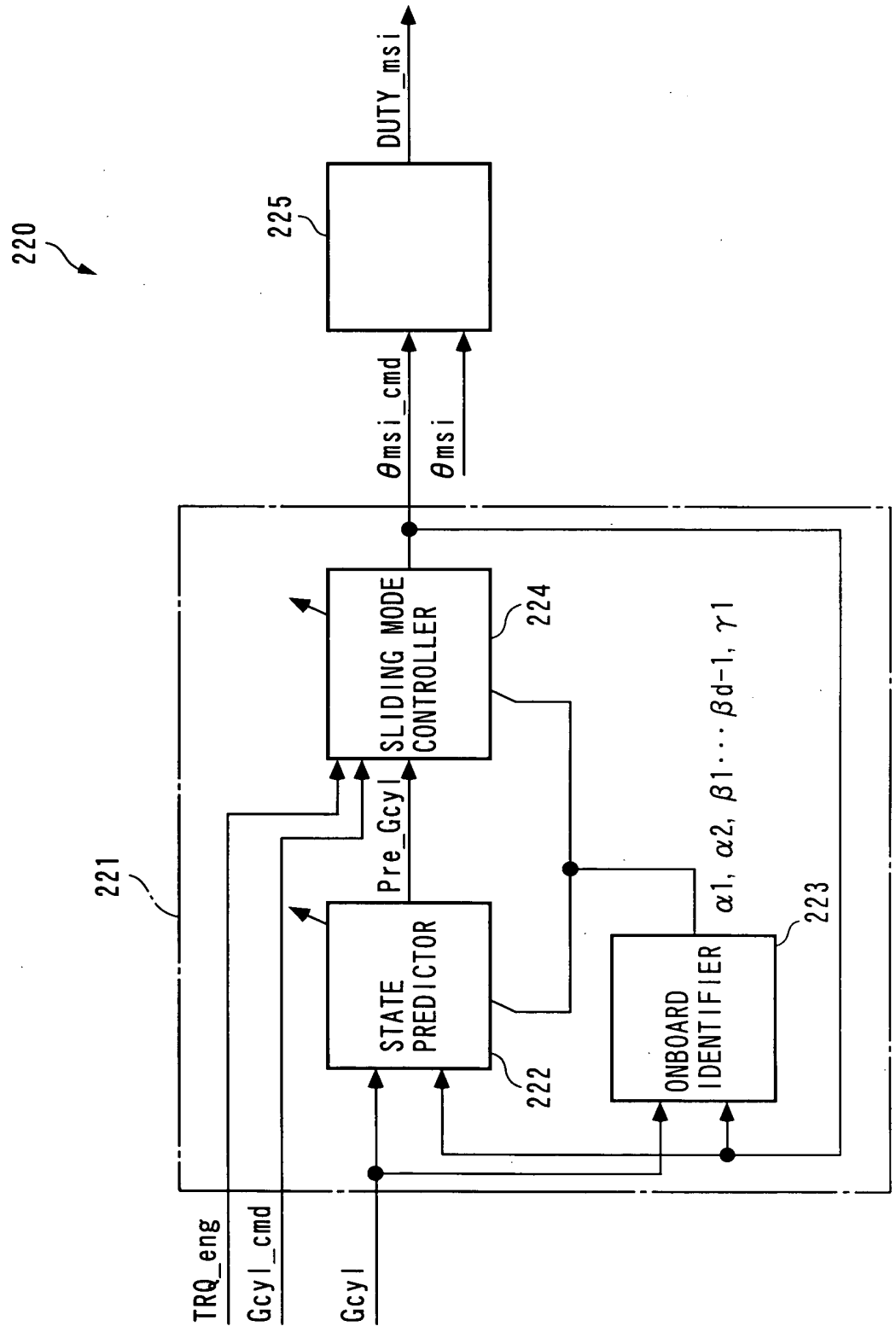

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FIG. 24

$$Gcyl(n)=Gth(n)-\frac{VB\cdot[PBA(n)-PBA(n-1)]}{R\cdot TB} \quad \cdots\cdots (1)$$

$$Gcyl(n)=a1\cdot Gcyl(n-1)+a2\cdot Gcyl(n-2)+b1\cdot \theta msi(n-d) \quad \cdots\cdots (2)$$

$$Gcyl(n+d-1)=a1\cdot Gcyl(n+d-2)+a2\cdot Gcyl(n+d-3)+b1\cdot \theta msi(n-1) \quad \cdots\cdots (3)$$

$$\boldsymbol{A}=\begin{bmatrix} a1 & a2 \\ 1 & 0 \end{bmatrix} \quad \cdots\cdots (4)$$

$$\boldsymbol{B}=\begin{bmatrix} b1 \\ 0 \end{bmatrix} \quad \cdots\cdots (5)$$

$$\begin{aligned} Gcyl(n+d-1)=&\alpha 1\cdot Gcyl(n)+\alpha 2\cdot Gcyl(n-1) \\ &+\beta 1\cdot \theta msi(n-1)+\beta 2\cdot \theta msi(n-2) \\ &+\cdots+\beta d-1\cdot \theta msi(n-d+1) \end{aligned} \quad \cdots\cdots (6)$$

$\alpha 1$: FIRST-ROW FIRST-COLUMN ELEMENT OF $\boldsymbol{A}^{d-1}$
$\alpha 2$: FIRST-ROW SECOND-COLUMN ELEMENT OF $\boldsymbol{A}^{d-1}$
βj : FIRST-ROW ELEMENT OF $\boldsymbol{A}^{j-1}\boldsymbol{B}$ $(j=0\sim d-1)$

$$\begin{aligned} Pre\_Gcyl(n)=&\alpha 1\cdot Gcyl(n)+\alpha 2\cdot Gcyl(n-1) \\ &+\beta 1\cdot \theta msi(n-1)+\beta 2\cdot \theta msi(n-2) \\ &+\cdots+\beta d-1\cdot \theta msi(n-d+1)+\gamma 1 \\ \fallingdotseq& Gcyl(n+d-1) \end{aligned} \quad \cdots\cdots (7)$$

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FIG. 25

$$\theta s(n)=\theta s(n-1)+KPs(n)\cdot ide(n) \qquad \cdots\cdots (8)$$

$$KPs(n)=\frac{Ps(n)\cdot \zeta s(n)}{1+\zeta s(n)^T\cdot Ps(n)\cdot \zeta s(n)} \qquad \cdots\cdots (9)$$

$$Ps(n+1)=\frac{1}{\lambda 1}\left[I-\frac{\lambda 2\cdot Ps(n)\cdot \zeta s(n)\cdot \zeta s(n)^T}{\lambda 1+\lambda 2\cdot \zeta s(n)^T\cdot Ps(n)\cdot \zeta s(n)}\right] Ps(n) \qquad \cdots\cdots (10)$$

I : UNIT MATRIX OF ORDER d+2
λ1, λ2 : WEIGHTING PARAMETER

$$ide(n)=Pre\_Gcyl(n-d+1)-Gcyl(n)$$
$$=\theta s(n-1)^T\cdot \zeta s(n)-Gcyl(n) \qquad \cdots\cdots (11)$$

$$\theta s(n)^T=[\alpha 1,\ \alpha 2,\ \beta 1,\ \beta 2,\ \cdots \beta d-1,\ \gamma 1] \qquad \cdots\cdots (12)$$

$$\zeta s(n)^T=[Gcyl(n-d),\ Gcyl(n-d-1),$$
$$\theta msi(n-d),\ \theta msi(n-d-1),\ \cdots,\ \theta msi(n-2d+2),\ 1] \qquad \cdots\cdots (13)$$

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FIG. 26

$$Gcyl(n+d)=\alpha 1\cdot Gcyl(n+1)+\alpha 2\cdot Gcyl(n)+\beta 1\cdot \theta msi(n)+\beta 2\cdot \theta msi(n-1)+\cdots+\beta d-1\cdot \theta msi(n-d+2)+\gamma 1 \quad \cdots\cdots (14)$$

$$Es(n)=Gcyl(n)-Gcyl\_cmd(n) \quad \cdots\cdots (15)$$

$$\sigma s(n)=Es(n)+Ss\cdot Es(n-1) \quad \cdots\cdots (16)$$

$$-1<Ss<0 \quad \cdots\cdots (17)$$

$$\theta msi\_cmd(n)=Uspas(n)=Ueq(n)+Urch(n)+Uvt(n) \quad \cdots\cdots (18)$$

$$Ueq(n)=\frac{1}{\beta 1}\{Pre\_Gcyl(n)+Ss\cdot Pre\_Gcyl(n-1)-\alpha 1\cdot Pre\_Gcyl(n-d+1)-\alpha 2\cdot Gcyl(n)-\beta 2\cdot \theta msi(n-1)-\cdots-\beta d-1\cdot \theta msi(n-d+2)-\gamma 1+Gcyl\_cmd(n+d)+(Ss-1)\cdot Gcyl\_cmd(n+d-1)-Ss\cdot Gcyl\_cmd(n+d-2)\} \quad \cdots\cdots (19)$$

$$Urch(n)=\frac{-F}{\beta 1}\cdot \sigma s(n+d-1) \quad \cdots\cdots (20)$$

F : REACHING LAW GAIN($0<F<2$)

$$Uvt(n)=\theta msi\_base(n) \quad \cdots\cdots (21)$$

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FIG. 27

$$\sigma s(n+d)=\sigma s(n+d-1) \qquad \cdots\cdots (22)$$

$$Es(n+d)+Ss\cdot Es(n+d-1)=Es(n+d-1)+Ss\cdot Es(n+d-2) \qquad \cdots\cdots (23)$$

$$\begin{aligned}&\alpha 1\cdot Gcyl(n+1)+\alpha 2\cdot Gcyl(n)+\beta 1\cdot \theta msi(n)+\beta 2\cdot \theta msi(n-1)\\&+\cdots+\beta d-1\cdot \theta msi(n-d+2)+\gamma 1-Gcyl\_cmd(n+d)\\&+Ss\cdot Gcyl(n+d-1)-Ss\cdot Gcyl\_cmd(n+d-1)\\&=Gcyl(n+d-1)-Gcyl\_cmd(n+d-1)\\&\quad+Ss\cdot Gcyl(n+d-2)-Ss\cdot Gcyl\_cmd(n+d-2)\end{aligned} \qquad \cdots\cdots (24)$$

$$\begin{aligned}\theta msi(n)=\frac{1}{\beta 1}\{&Gcyl(n+d-1)+Ss\cdot Gcyl(n+d-2)\\&-\alpha 1\cdot Gcyl(n+1)-\alpha 2\cdot Gcyl(n)\\&-\beta 2\cdot \theta msi(n-1)-\cdots-\beta d-1\cdot \theta msi(n-d+2)-\gamma 1\\&+Gcyl\_cmd(n+d)+(Ss-1)\cdot Gcyl\_cmd(n+d-1)\\&-Ss\cdot Gcyl\_cmd(n+d-2)\}\end{aligned} \qquad \cdots\cdots (25)$$

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FIG. 28

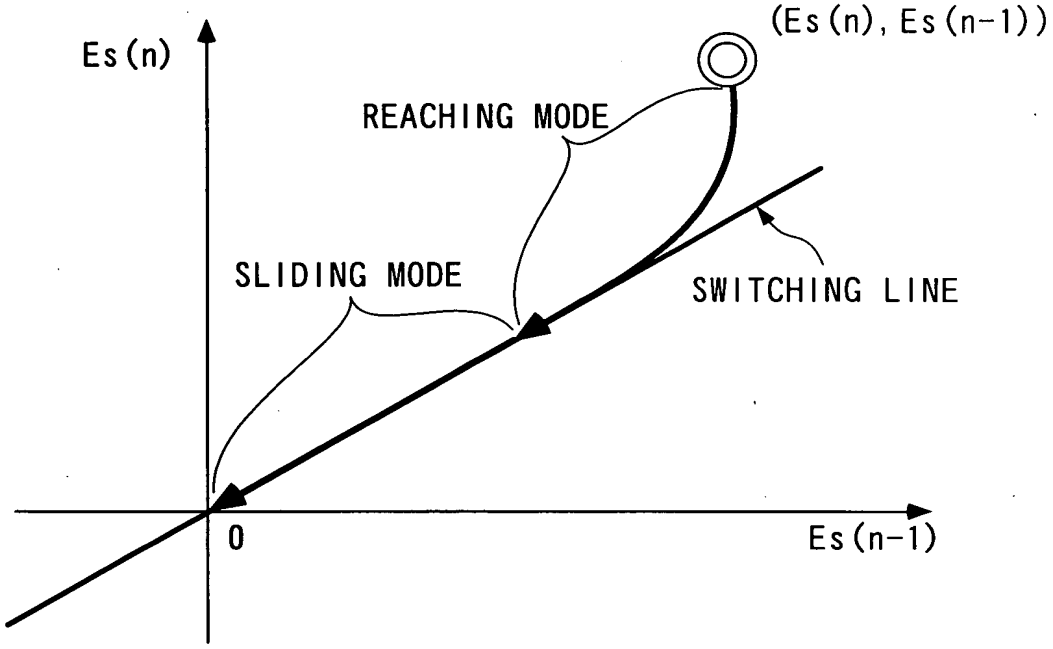

FIG. 29

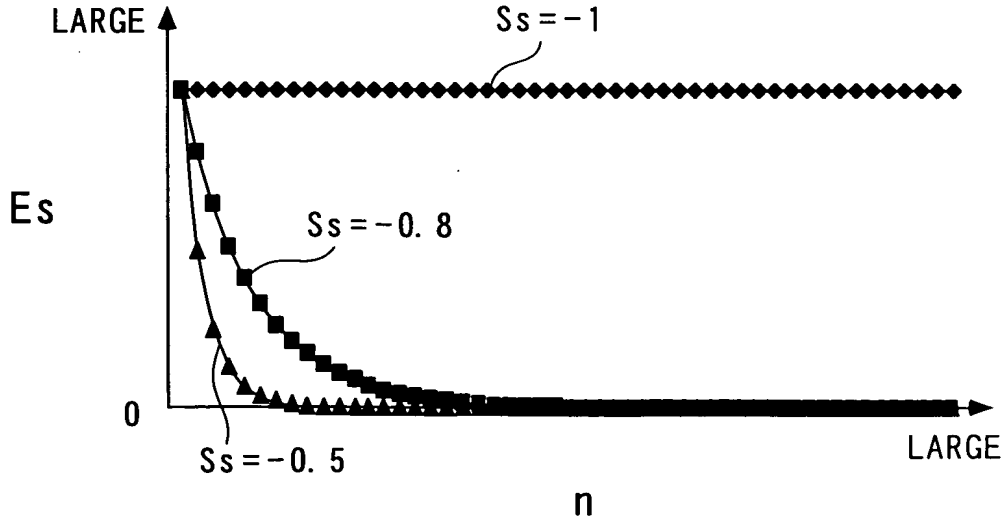

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FIG. 30

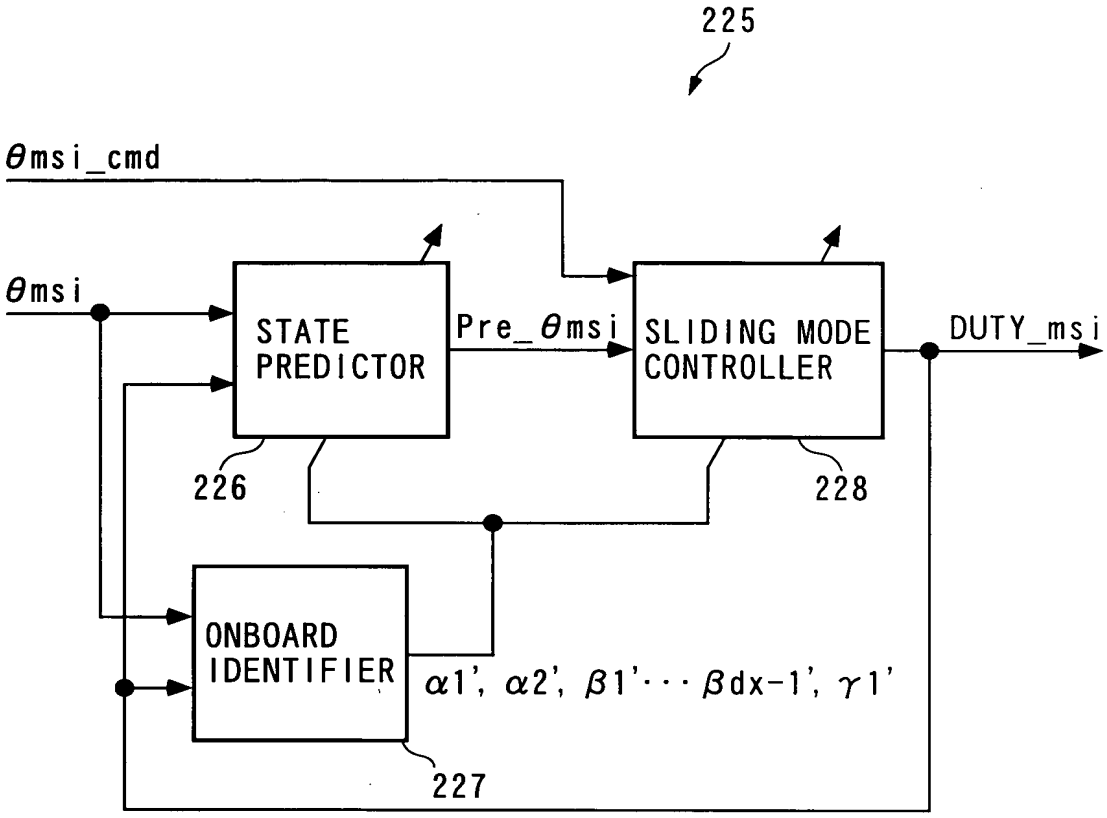

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FIG. 31

$$\theta msi(m)=a1'\cdot\theta msi(m-1)+a2'\cdot\theta msi(m-2)+b1'\cdot DUTY\_msi(m-dx) \quad \cdots\cdots (26)$$

$$\boldsymbol{A'}=\begin{bmatrix} a1' & a2' \\ 1 & 0 \end{bmatrix} \quad \cdots\cdots (27)$$

$$\boldsymbol{B'}=\begin{bmatrix} b1' \\ 0 \end{bmatrix} \quad \cdots\cdots (28)$$

$$\begin{aligned} Pre\_\theta msi(m) = {} & \alpha1'\cdot\theta msi(m)+\alpha2'\cdot\theta msi(m-1) \\ & +\beta1'\cdot DUTY\_msi(m-1)+\beta2'\cdot DUTY\_msi(m-2) \\ & +\cdots+\beta dx-1'\cdot DUTY\_msi(m-dx+1)+\gamma1' \\ \fallingdotseq {} & \theta msi(m+dx-1) \end{aligned} \quad \cdots\cdots (29)$$

$\alpha1'$: FIRST-ROW FIRST-COLUMN ELEMENT OF $\boldsymbol{A'}^{dx-1}$
$\alpha2'$: FIRST-ROW SECOND-COLUMN ELEMENT OF $\boldsymbol{A'}^{dx-1}$
$\beta j'$: FIRST-ROW ELEMENT OF $\boldsymbol{A'}^{j'-1}\boldsymbol{B'}$ ($j'=0\sim dx-1$)

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FIG. 32

$$\theta s'(m)=\theta s'(m-1)+KPs'(m)\cdot ide'(m) \qquad \cdots\cdots (30)$$

$$KPs'(m)=\frac{Ps'(m)\cdot \zeta s'(m)}{1+\zeta s'(m)^T\cdot Ps'(m)\cdot \zeta s'(m)} \qquad \cdots\cdots (31)$$

$$Ps'(m+1)=\frac{1}{\lambda 1'}\left[I'-\frac{\lambda 2'\cdot Ps'(m)\cdot \zeta s'(m)\cdot \zeta s'(m)^T}{\lambda 1'+\lambda 2'\cdot \zeta s'(m)^T\cdot Ps'(m)\cdot \zeta s'(m)}\right]Ps'(m) \qquad \cdots\cdots (32)$$

I': UNIT MATRIX OF ORDER dx+2
λ1', λ2': WEIGHTING PARAMETER

$$ide'(m)=Pre\_\theta msi(m-dx+1)-\theta msi(m)$$
$$=\theta s'(m-1)^T\cdot \zeta s'(m)-\theta msi(m) \qquad \cdots\cdots (33)$$

$$\theta s'(m)^T=[\alpha 1', \alpha 2', \beta 1', \beta 2', \cdots \beta dx-1', \gamma 1'] \qquad \cdots\cdots (34)$$

$$\zeta s'(m)^T=[\theta msi(m-dx), \theta msi(m-dx-1), DUTY\_msi(m-dx), DUTY\_msi(m-dx-1), \cdots \cdots, DUTY\_msi(m-2dx+2), 1] \qquad \cdots\cdots (35)$$

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FIG. 33

$$Es'(m)=\theta msi(m)-\theta msi\_cmd(m) \quad \cdots\cdots (36)$$

$$\sigma s'(m)=Es'(m)+Ss'\cdot Es'(m-1) \quad \cdots\cdots (37)$$

$$-1<Ss'<0 \quad \cdots\cdots (38)$$

$$DUTY\_msi(m)=Uspas'(m)=Ueq'(m)+Urch'(m) \quad \cdots\cdots (39)$$

$$\begin{aligned}Ueq'(m)=\frac{1}{\beta 1'}\{&Pre\_\theta msi(m)+Ss'\cdot Pre\_\theta msi(m-1)\\&-\alpha 1'\cdot Pre\_\theta msi(m-dx+1)-\alpha 2'\cdot\theta msi(m)\\&-\beta 2'\cdot DUTY\_msi(m-1)-\cdots-\beta dx-1'\cdot DUTY\_msi(m-dx+2)-\gamma 1'\\&+\theta msi\_cmd(m+dx)+(Ss'-1)\cdot\theta msi\_cmd(m+dx-1)\\&-Ss'\cdot\theta msi\_cmd(m+dx-2)\}\end{aligned} \quad \cdots\cdots (40)$$

$$Urch'(n)=\frac{-F'}{\beta 1'}\cdot\sigma s'(m+dx-1) \quad \cdots\cdots (41)$$

F' : REACHING LAW GAIN $(0<F'<2)$

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FIG. 34

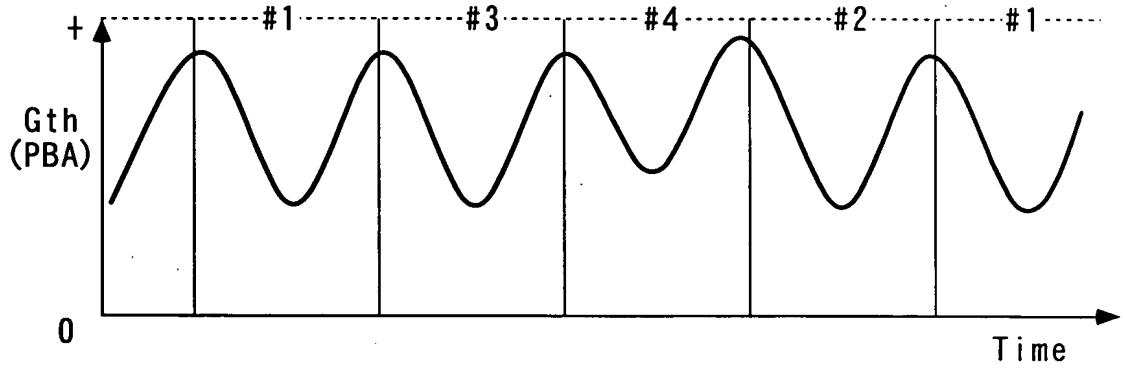

FIG. 35

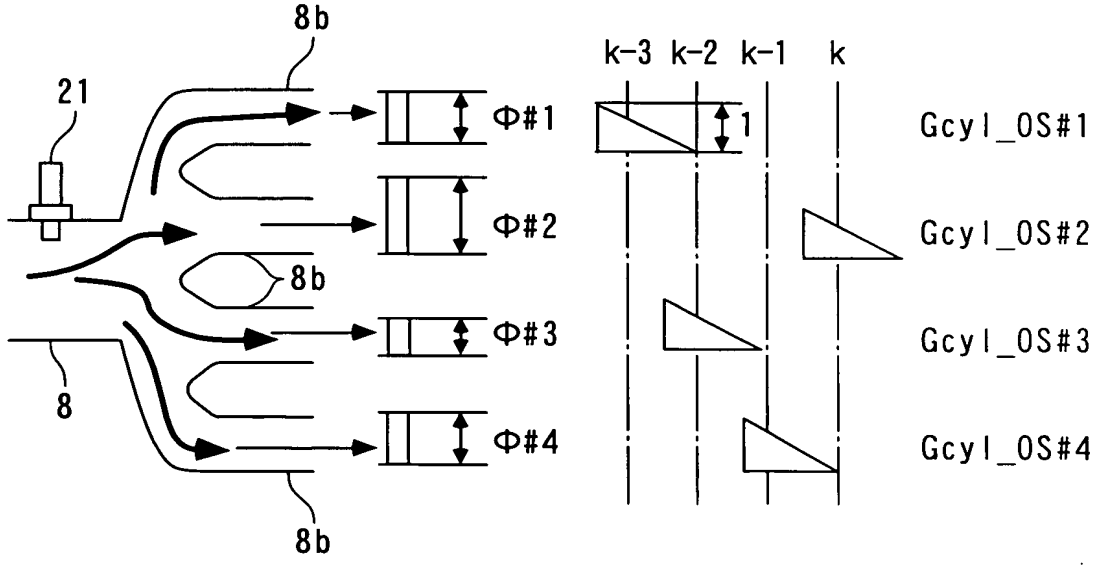

FIG. 36

$$Gth(k-d') = \Phi\#1(k) \cdot Gcyl\_OS\#1(k) + \Phi\#2(k) \cdot Gcyl\_OS\#2(k) + \Phi\#3(k) \cdot Gcyl\_OS\#3(k) + \Phi\#4(k) \cdot Gcyl\_OS\#4(k) \quad \cdots\cdots (42)$$

$$Gth\_est(k) = \Phi\#1(k) \cdot Gcyl\_OS\#1(k) + \Phi\#2(k) \cdot Gcyl\_OS\#2(k) + \Phi\#3(k) \cdot Gcyl\_OS\#3(k) + \Phi\#4(k) \cdot Gcyl\_OS\#4(k) \quad \cdots\cdots (43)$$

$$\phi(k) = \phi(k-1) + KR(k) \cdot ide'(k) \quad \cdots\cdots (44)$$

$$KR(k) = \frac{R(k) \cdot \zeta'(k)}{1 + \zeta'(k)^T \cdot R(k) \cdot \zeta'(k)} \quad \cdots\cdots (45)$$

$$ide'(k) = Gth(k-d') - Gth\_est(k) \quad \cdots\cdots (46)$$

$$Gth\_est(k) = \phi(k-1)^T \zeta'(k) \quad \cdots\cdots (47)$$

$$R(k+1) = \frac{1}{\lambda 1''} \left[I - \frac{\lambda 2'' \cdot R(k) \cdot \zeta'(k) \cdot \zeta'(k)^T}{\lambda 1'' + \lambda 2'' \cdot \zeta'(k)^T \cdot R(k) \cdot \zeta'(k)} \right] R(k) \quad \cdots\cdots (48)$$

I: UNIT MATRIX
$\lambda 1''$, $\lambda 2''$: WEIGHTING PARAMETER

$$\phi(k)^T = [\Phi\#1(k), \Phi\#2(k), \Phi\#3(k), \Phi\#4(k)] \quad \cdots\cdots (49)$$

$$\zeta'(k)^T = [Gcyl\_OS\#1(k), Gcyl\_OS\#2(k), Gcyl\_OS\#3(k), Gcyl\_OS\#4(k)] \quad \cdots\cdots (50)$$

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FIG. 37

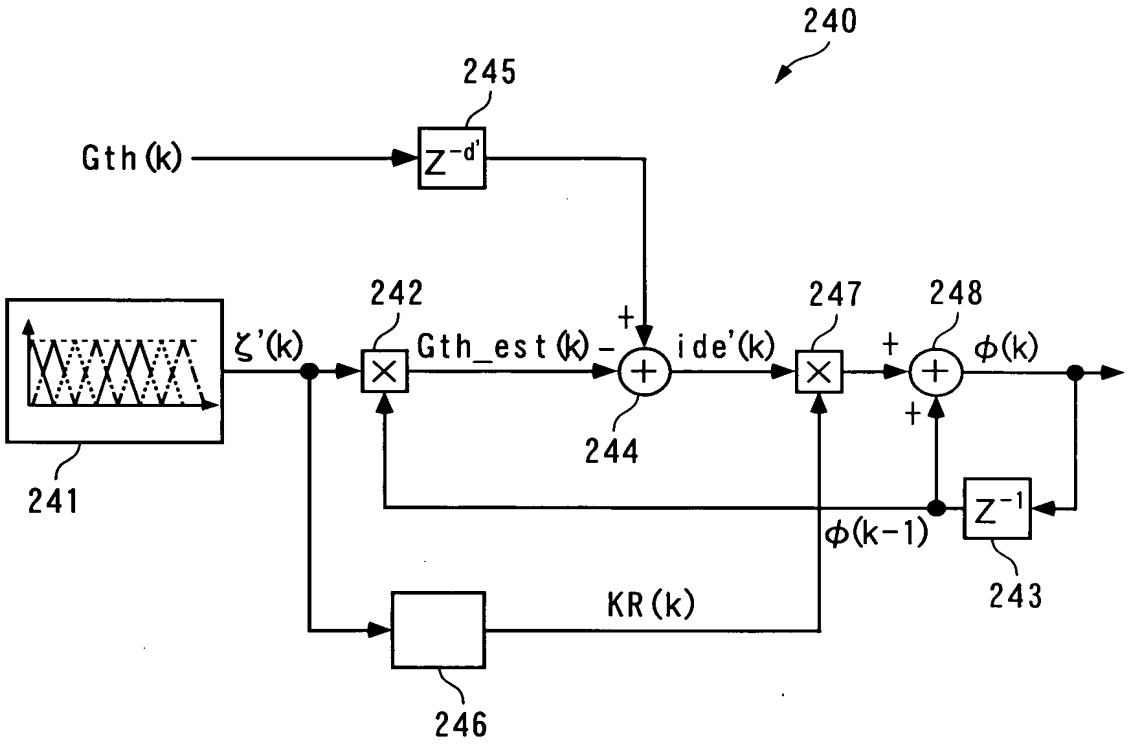

FIG. 38

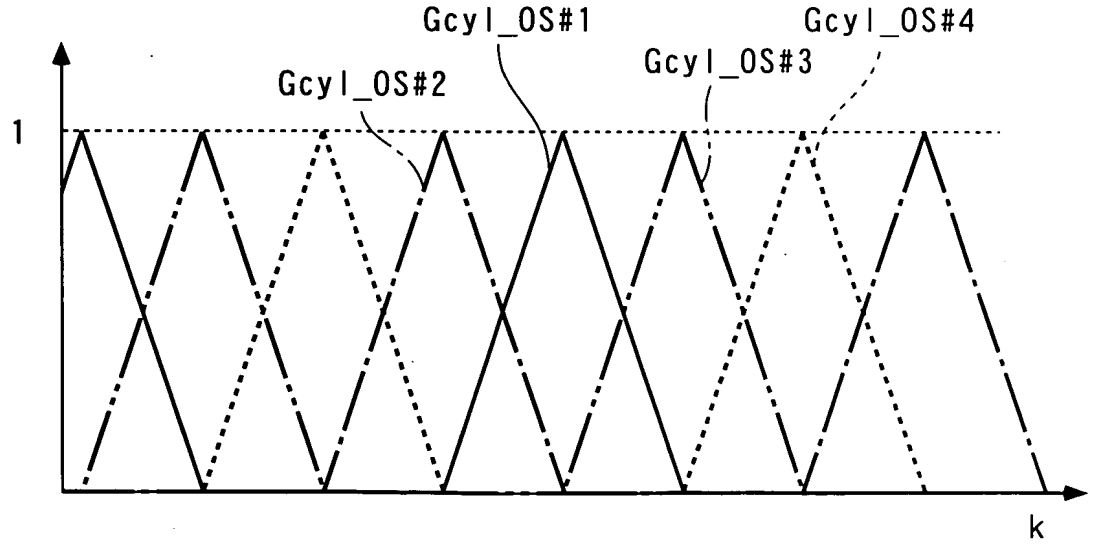

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FIG. 39

$$E\Phi\#i(k)=\Phi\#i(k)-\Phi\#1(k) \quad (i=2\sim4) \qquad \cdots\cdots (51)$$

$$\sigma'(k)=E\Phi\#i(k)+S'E\Phi\#i(k-1) \qquad \cdots\cdots (52)$$

$$\theta ss\#i\_cmd(k)=-Fs'\cdot\sigma'(k)-Gs'\cdot\sum_{j=0}^{k}\sigma'(j)-Hs'\cdot E\Phi\#i(k) \qquad \cdots\cdots (53)$$

Fs', Gs', Hs' : FEEDBACK GAIN
S' : SWITCHING FUNCTION-SETTING PARAMETER ($-1<S'<1$)

FIG. 40

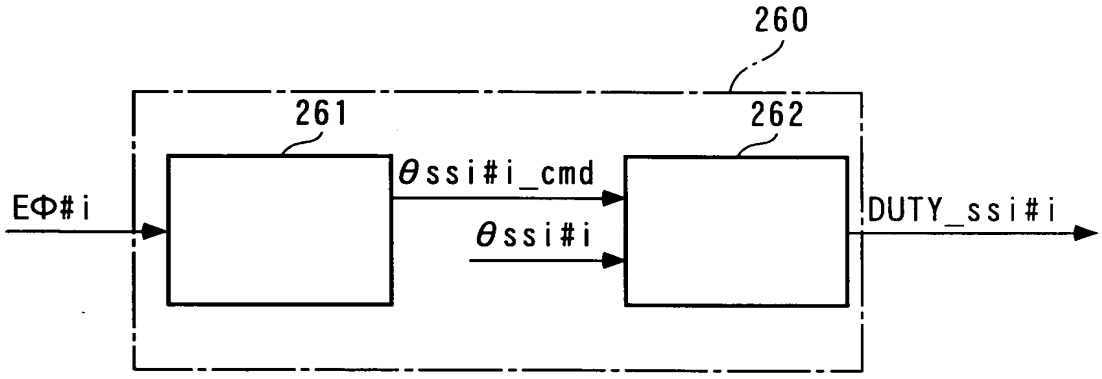

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FIG. 41

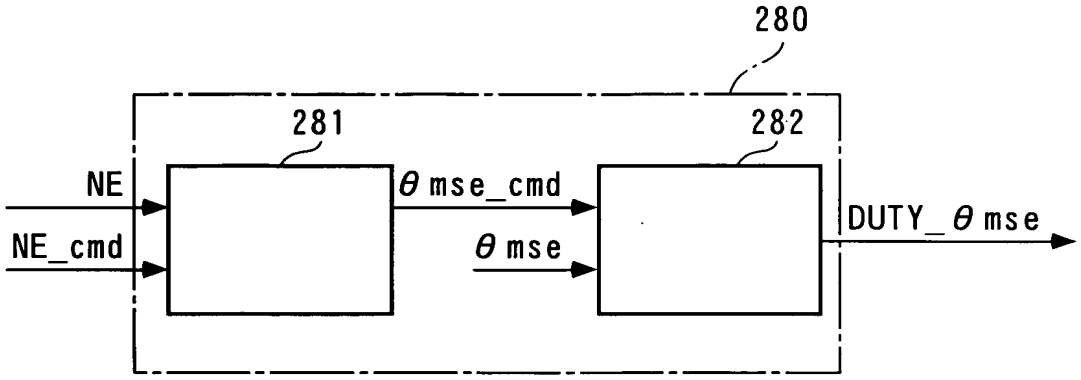

FIG. 42

$$\theta mse\_cmd(n)=\theta mse\_ast(n)+d\theta mse(n) \quad \cdots\cdots (54)$$

$$d\theta mse(n)=-Kastr\cdot\sigma ast(n)+\left[-Kasta\cdot\sum_{i=0}^{n}\sigma ast(i)\right] \quad \cdots\cdots (55)$$

$$\sigma ast(n)=NE(n)-NE\_cmd(n)+Sast\cdot[NE(n-1)-NE\_cmd(n-1)] \quad \cdots\cdots (56)$$

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FIG. 43

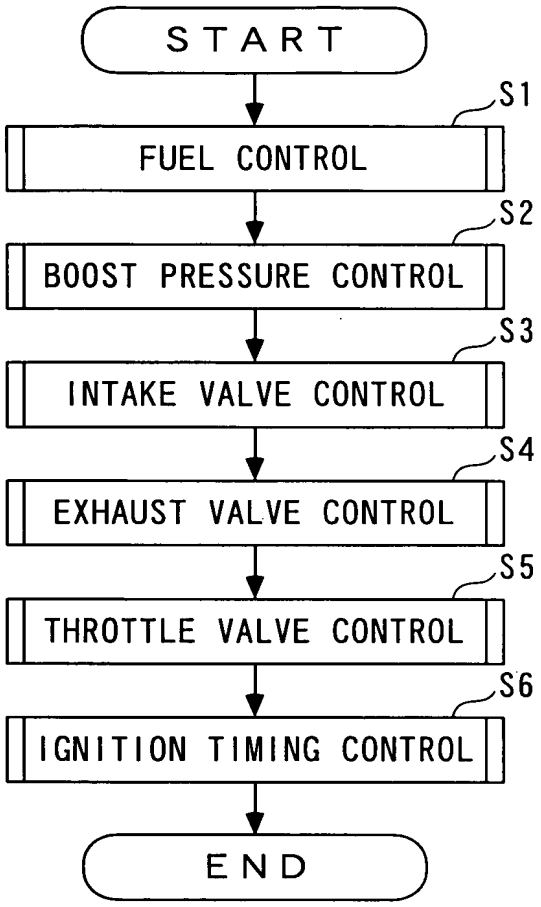

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FIG. 44

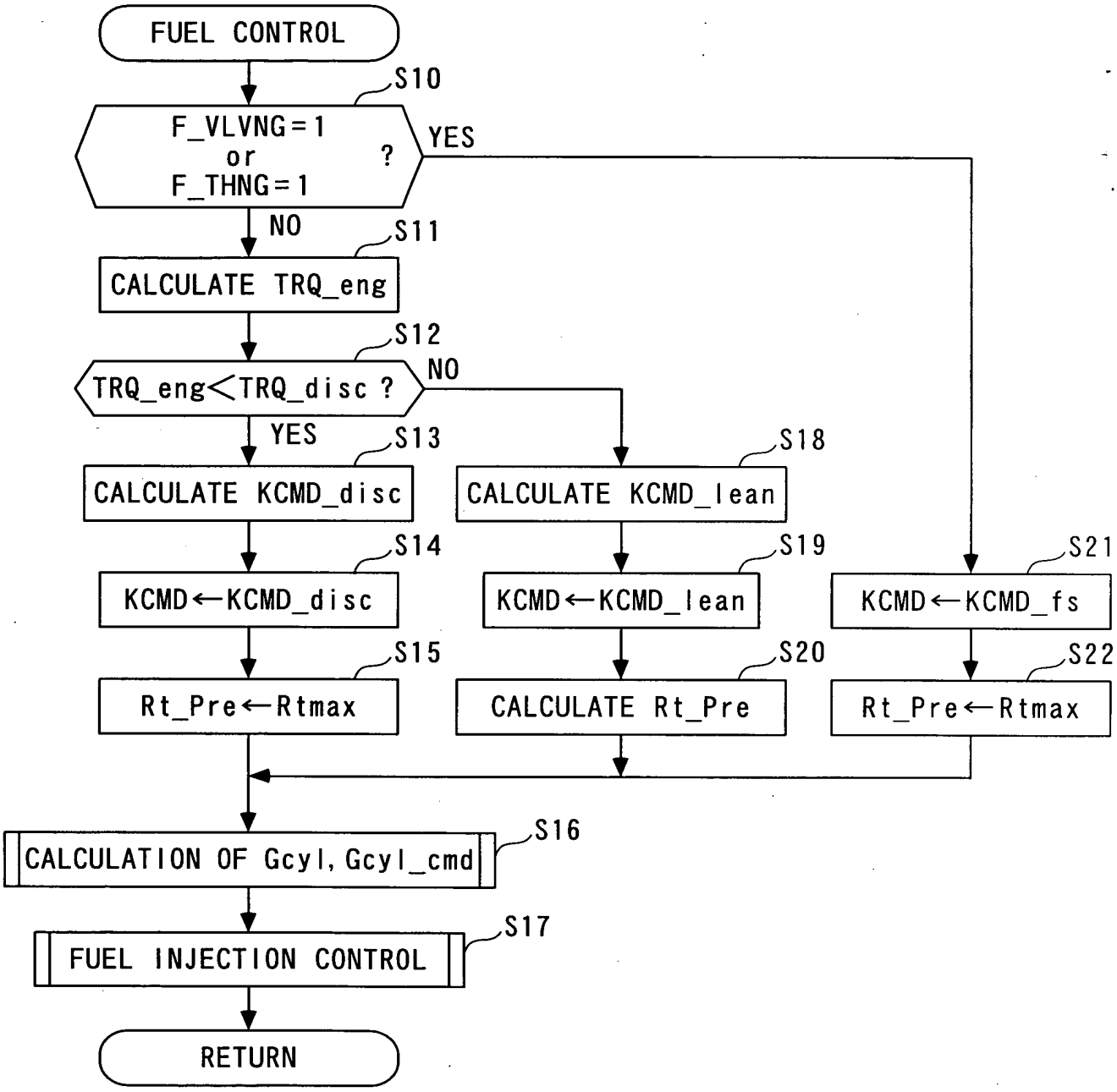

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FIG. 45

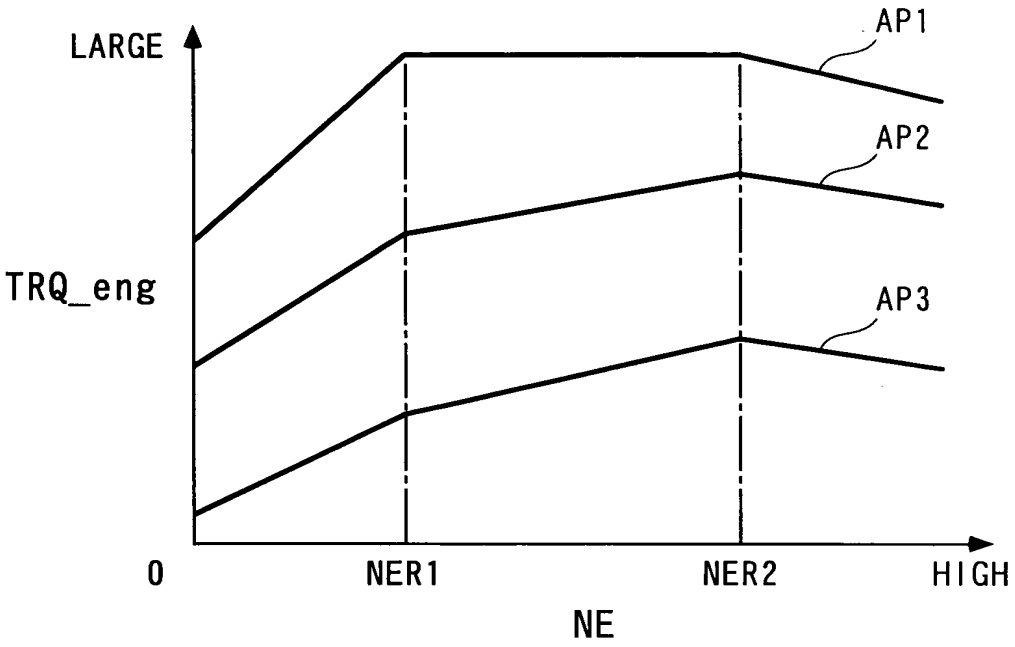

FIG. 46

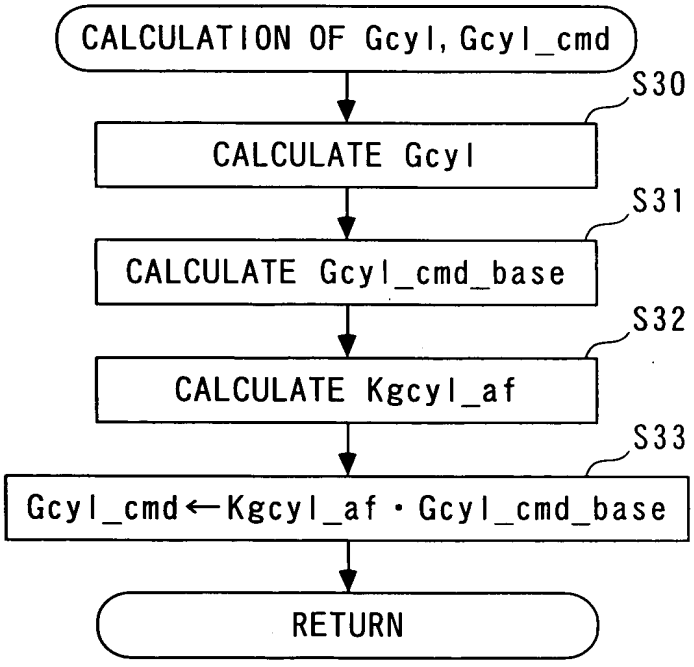

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FIG. 47

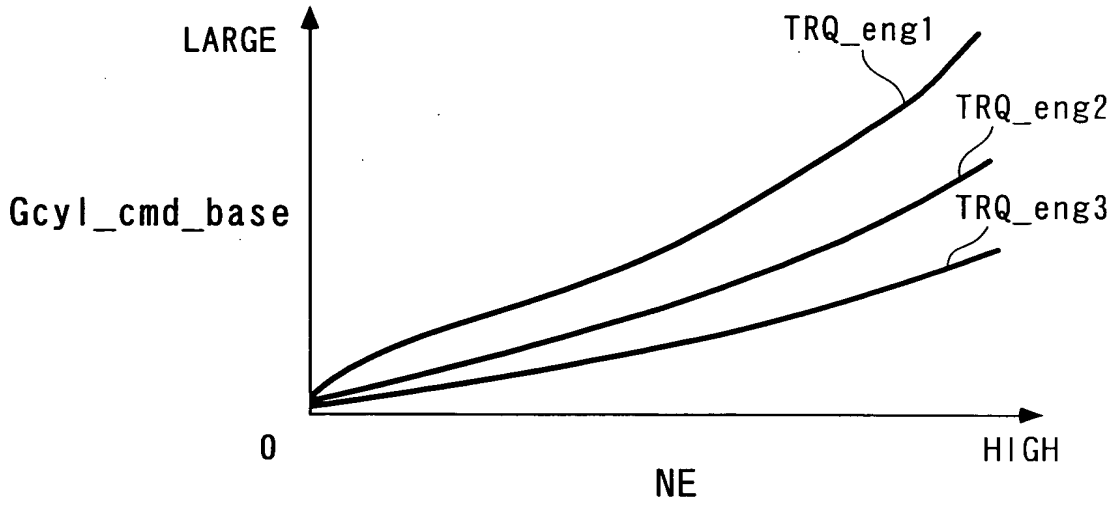

FIG. 48

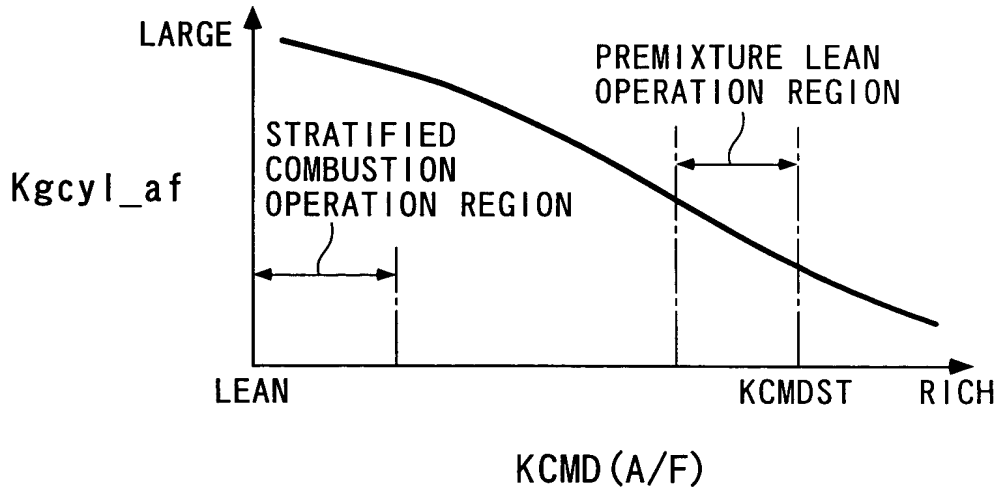

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FIG. 49

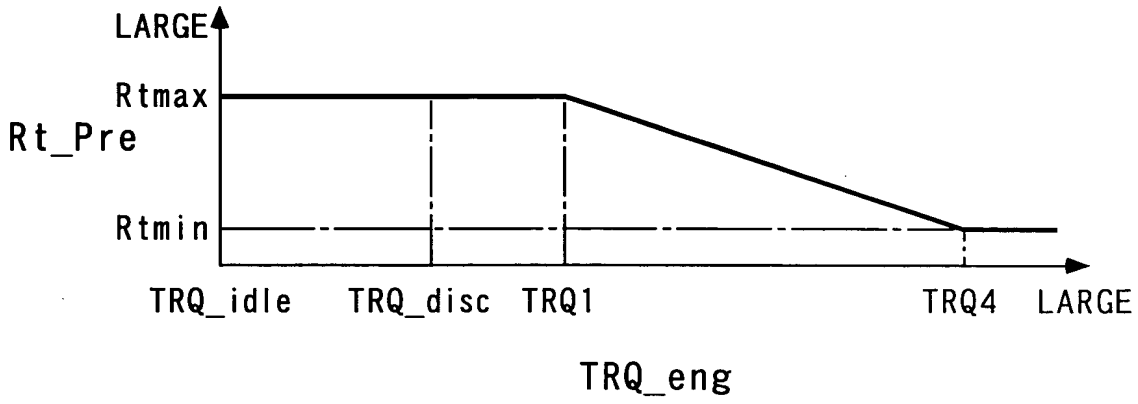

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FIG. 50

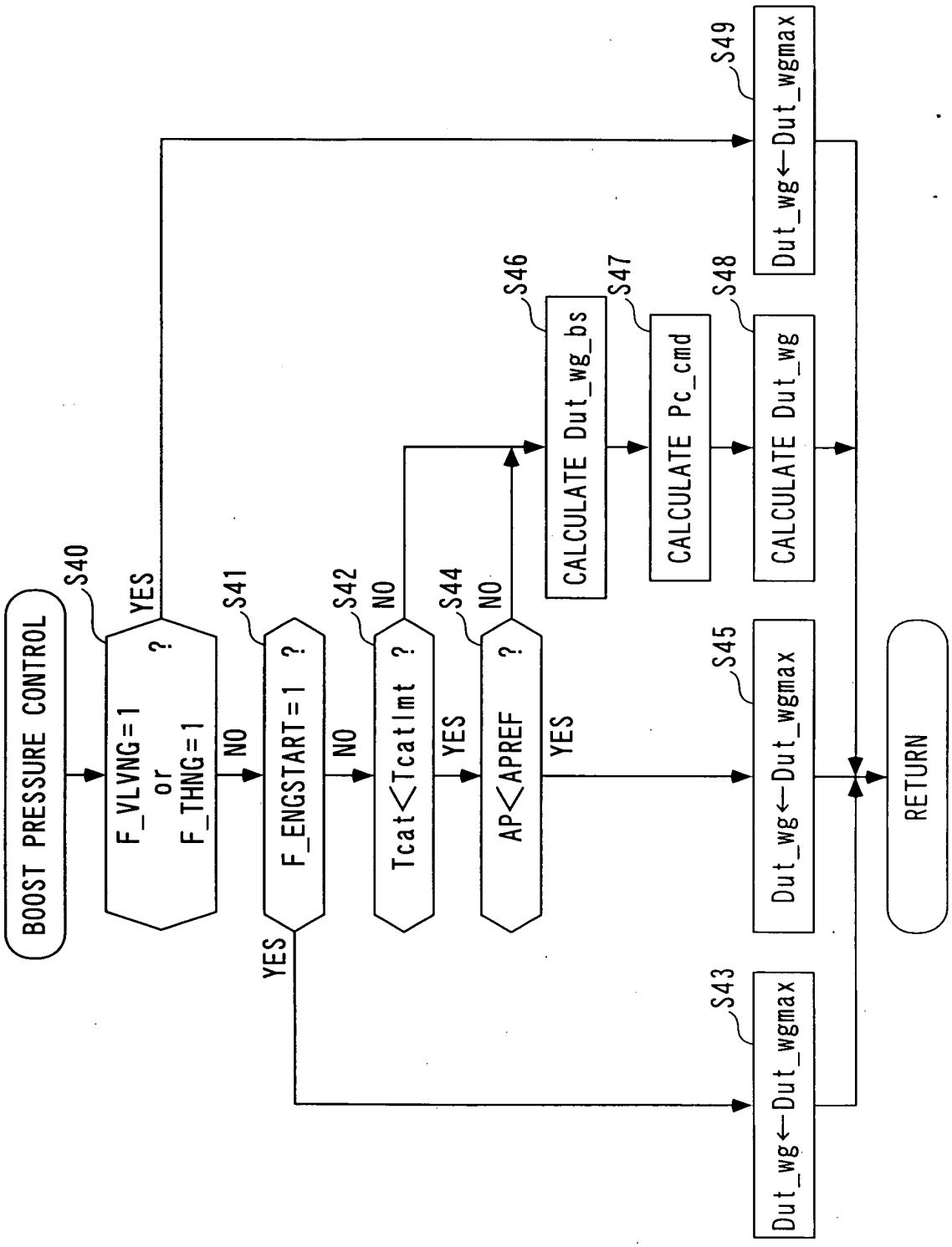

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FIG. 51

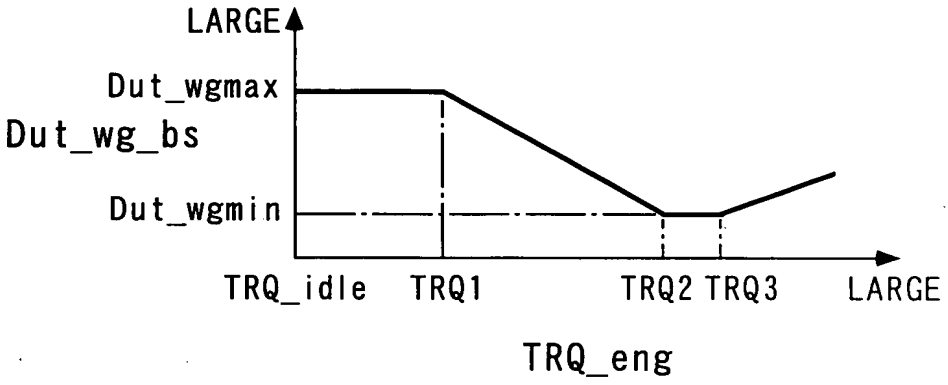

FIG. 52

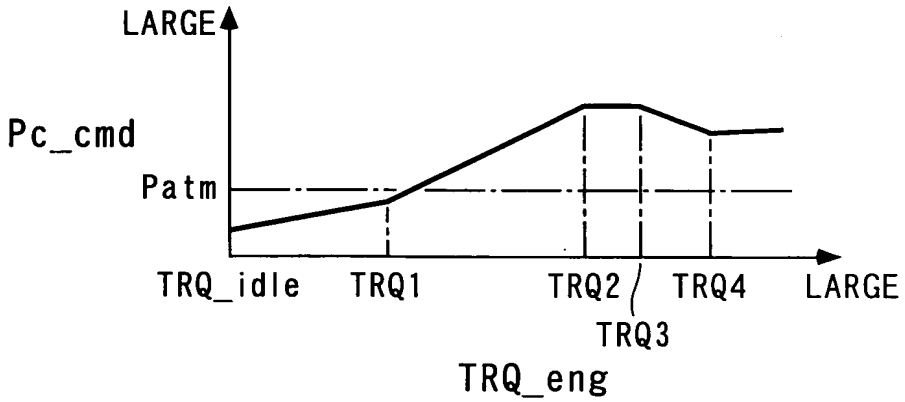

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FIG. 53

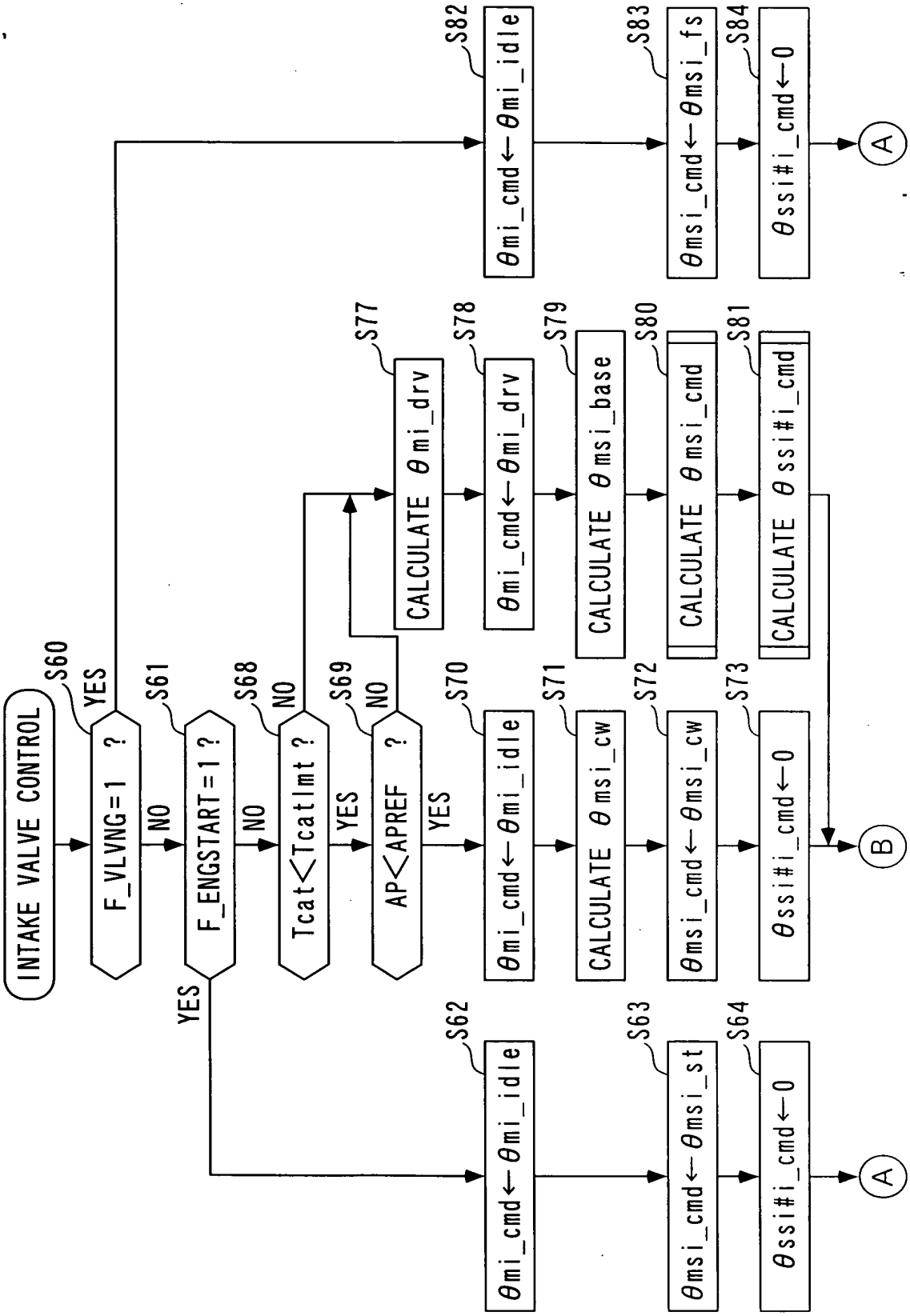

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FIG. 54

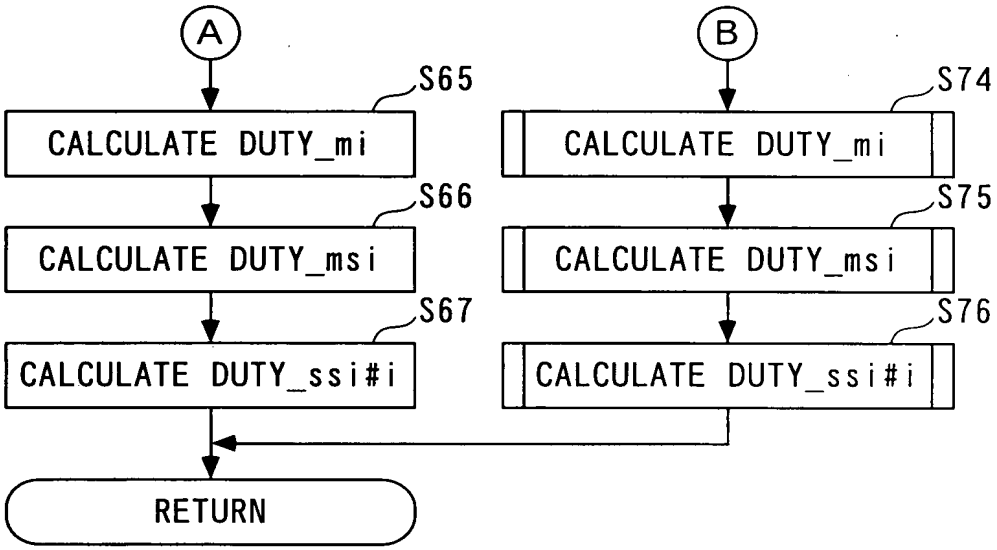

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FIG. 55

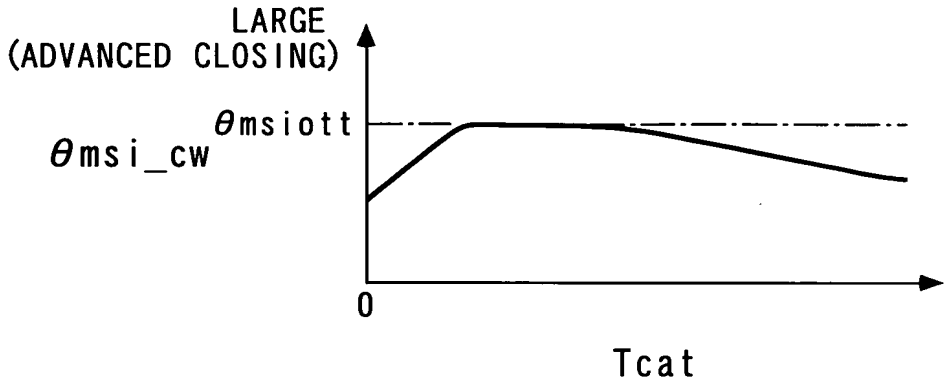

FIG. 56

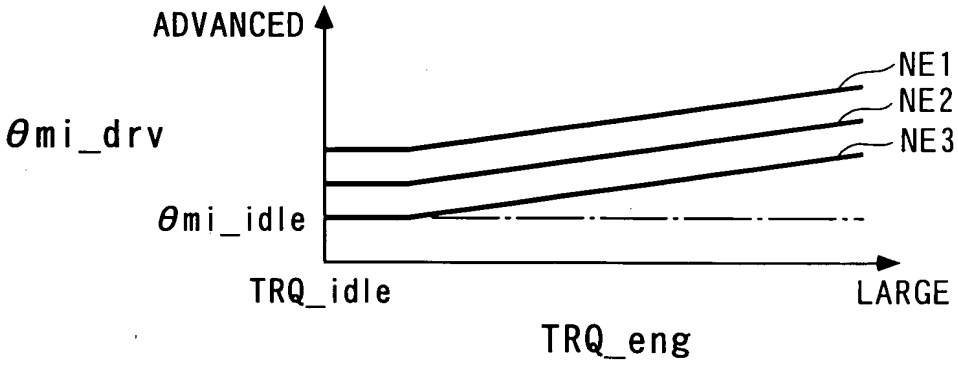

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FIG. 57

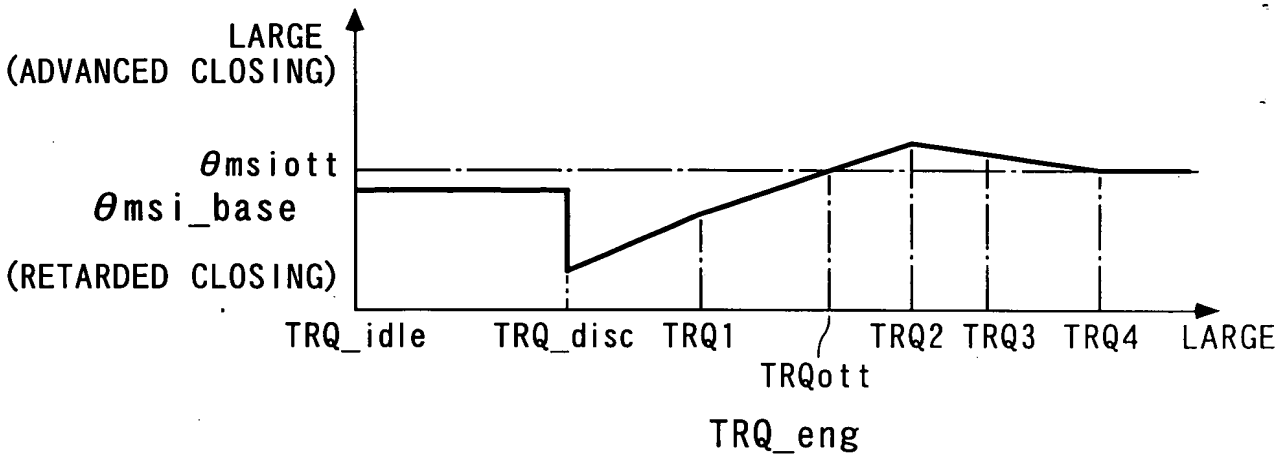

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FIG. 58

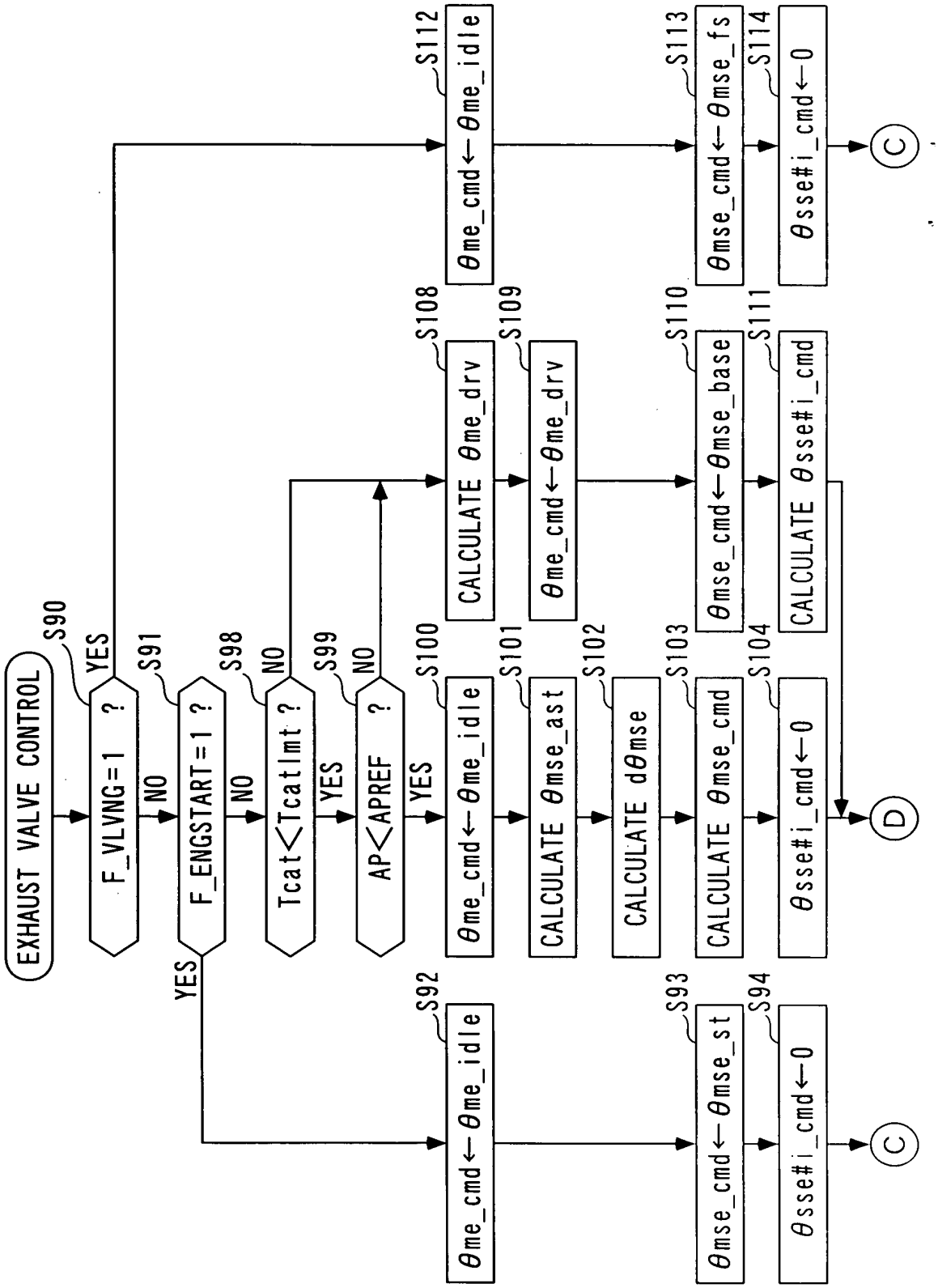

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FIG. 59

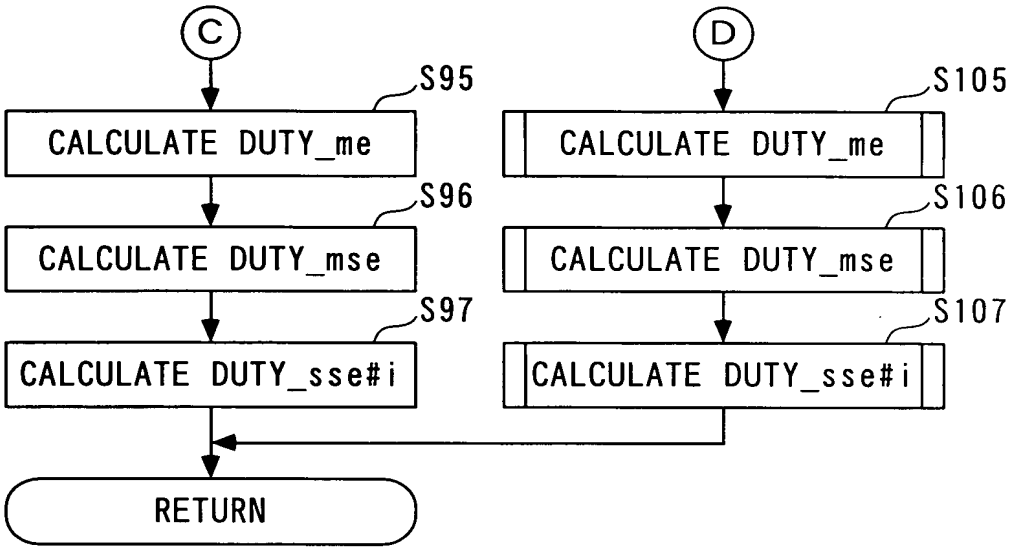

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FIG. 60

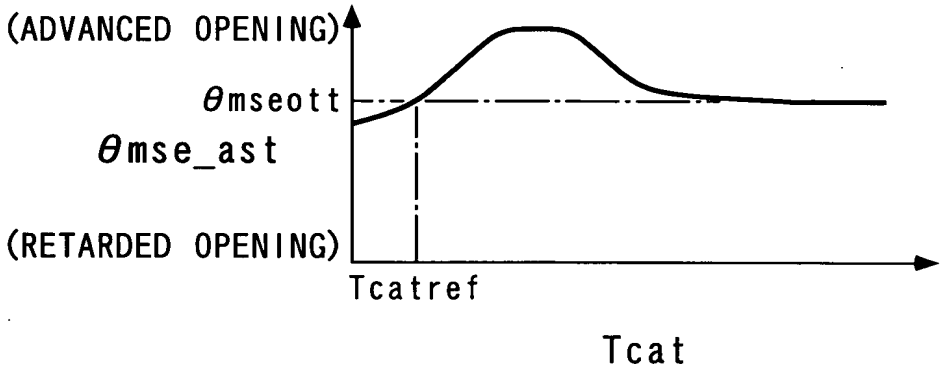
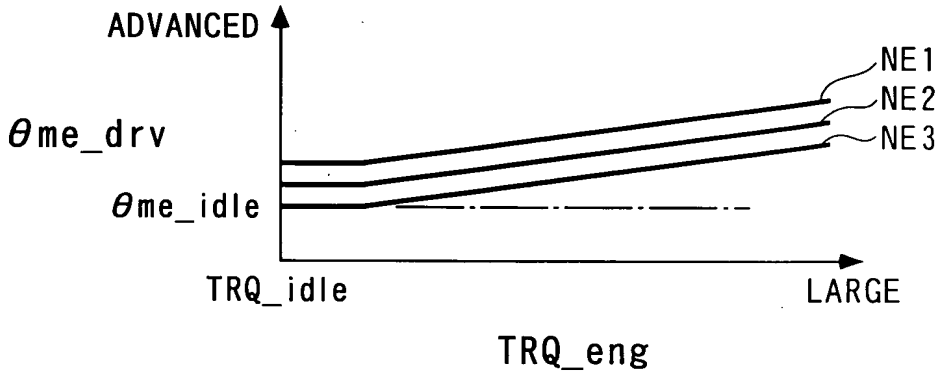


FIG. 61



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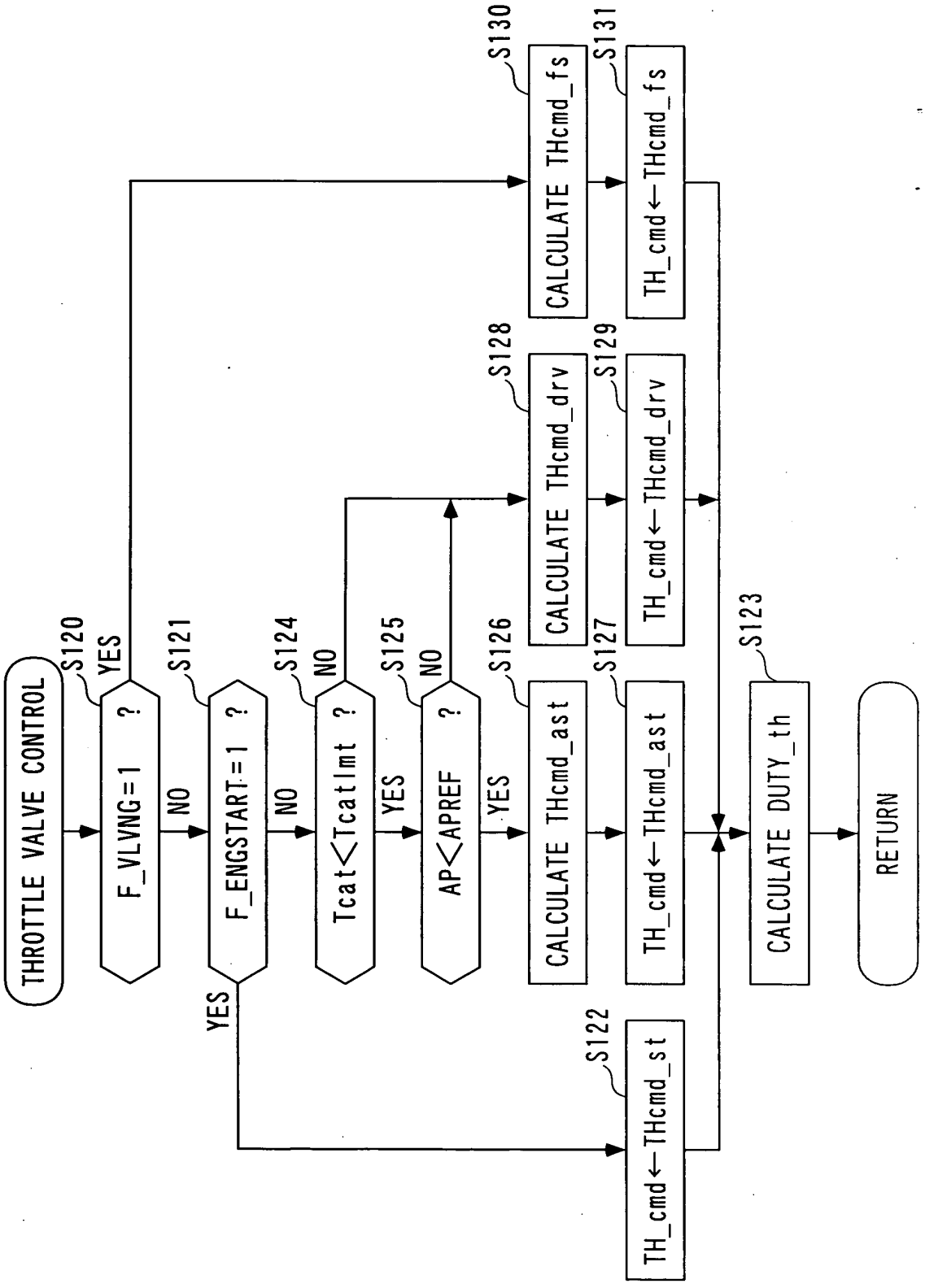

FIG. 63

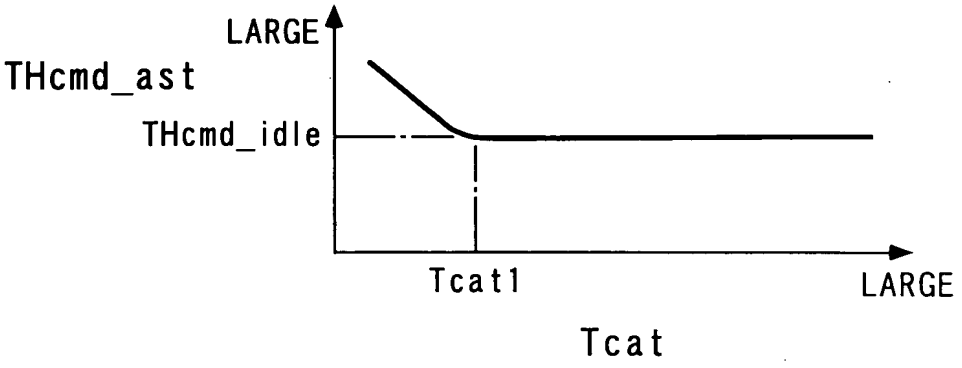

FIG. 64

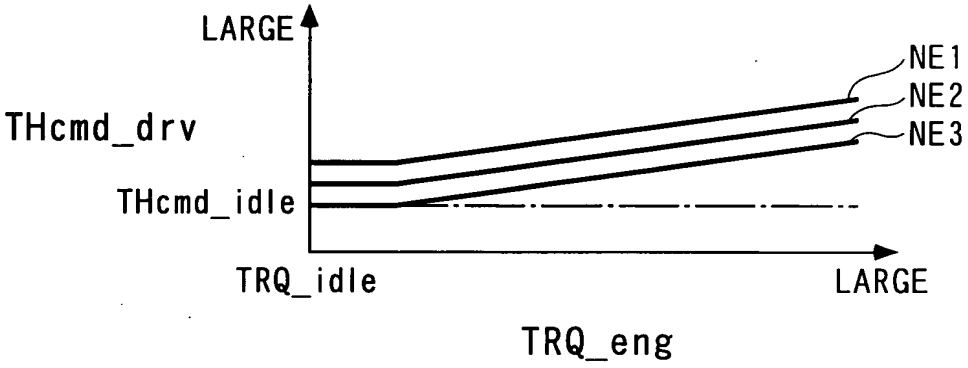

FIG. 65

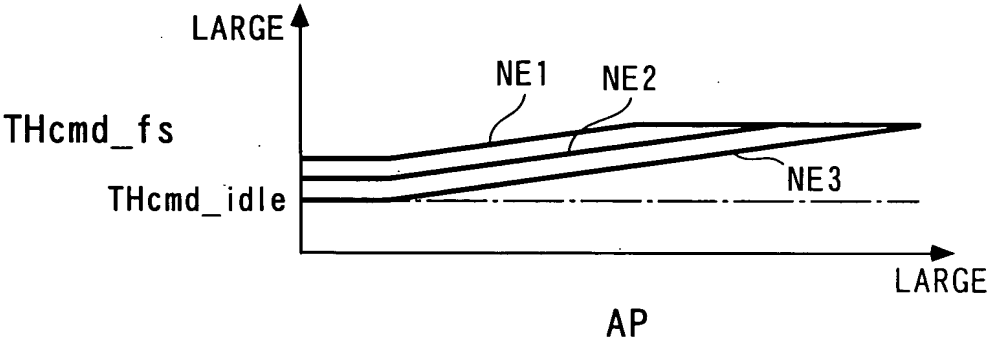

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FIG. 66

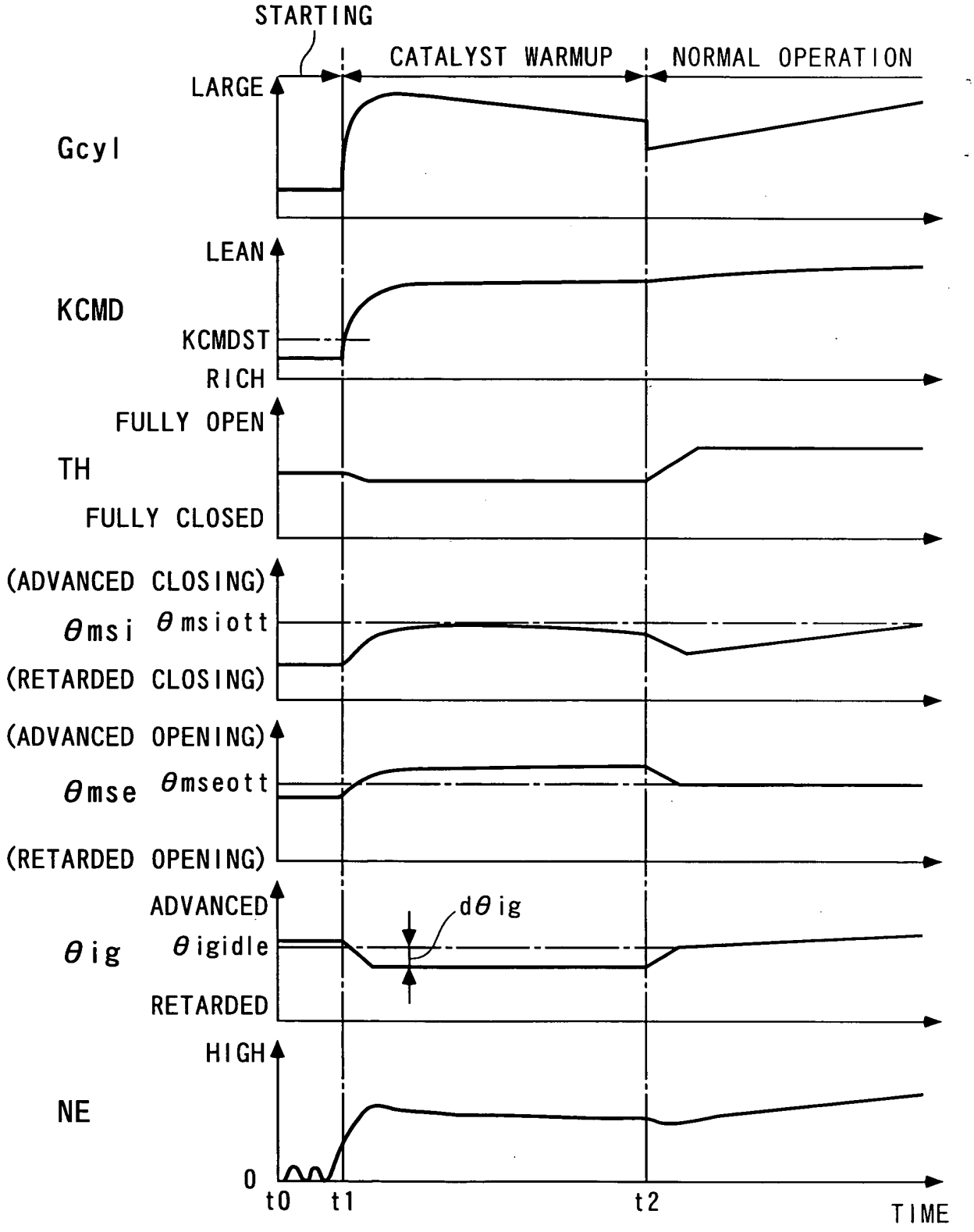

FIG. 67

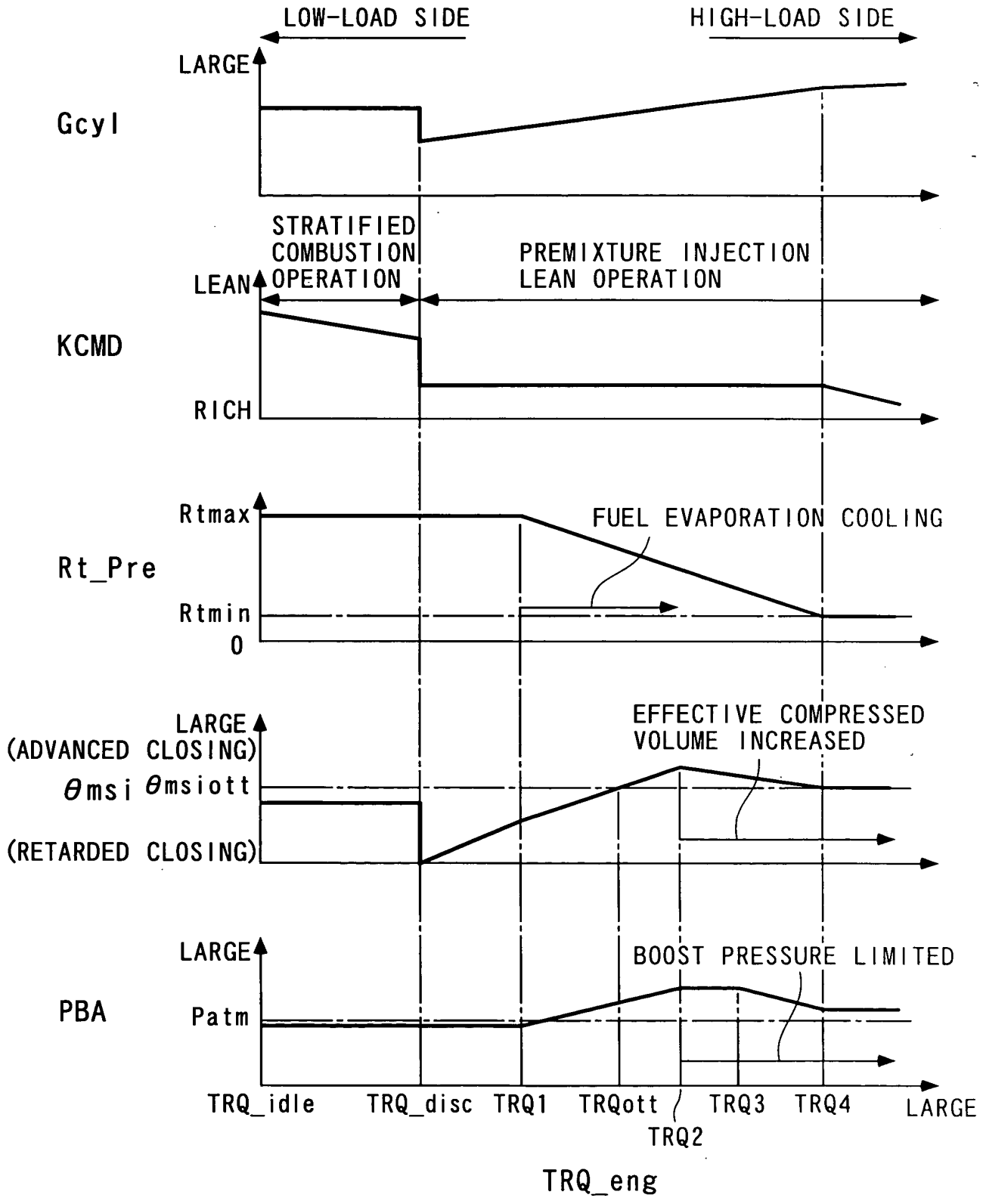
LOW-LOAD SIDE
HIGH-LOAD SIDE
LARGE
Gcyl
STRATIFIED COMBUSTION OPERATION
PREMIXTURE INJECTION LEAN OPERATION
LEAN
KCMD
RICH
Rtmax
FUEL EVAPORATION COOLING
Rt_Pre
Rtmin
0
LARGE
(ADVANCED CLOSING)
θmsi
θmsiott
(RETARDED CLOSING)
EFFECTIVE COMPRESSED VOLUME INCREASED
LARGE
BOOST PRESSURE LIMITED
PBA
Patm
TRQ_idle
TRQ_disc
TRQ1
TRQott
TRQ2
TRQ3
TRQ4
LARGE
TRQ_eng

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FIG. 68